Printed on Thin Paper for Foreign Circulation.

The Engineer.

Established 1856.

Registered as a Newspaper.

OFFICE FOR ADVERTISEMENTS & PUBLICATION, 28, ESSEX ST., STRAND, LONDON, W.C. 2.

VOL. CLIII.—No. 3978] LONDON: FRIDAY EVENING, APRIL 8, 1932 [PRICE WITH SUPPLEMENT ONE SHILLING BY INLAND POST 1s. 3d.

PUBLIC NOTICES.

Assistant Civil Engineers REQUIRED in Civil Engineer-in-Chief's Department, Admiralty, and H.M. Naval Establishments at home and abroad. Candidates must be between the ages of twenty-five and and thirty years on the 14th May, 1932 those who have served, or are serving, in the Royal Navy, Army, or Royal Air Force may deduct from their actual age any time, not exceeding three years, during which they have so served. Candidates must either (1) be Corporate Members of the Institution of Civil Engineers, or (2) have passed Sections A and B of the Associate Membership Examination of the Institution of Civil Engineers, or taken a degree recognised by the Institution as exempting therefrom, and have reached such a stage in their professional training that it is possible for them to become Corporate Members within two years.

Those appointed will be on probation for two years, and will not be confirmed unless and until they, being Corporate Members of the Institution of Civil Engineers, have passed this period of probation to the satisfaction of the Admiralty.

Commencing salary £250 per annum plus Civil Service bonus, which at the current rate amounts to £79 per annum.

Special consideration will be given to candidates who served in H.M. Forces during the war.

No candidate will be accepted for appointment who fails to pass a strict medical examination as to his physical fitness.

Forms of application, &c., can be obtained from the CIVIL ENGINEER-IN-CHIEF, Admiralty, London, S.W. 1, and should be returned completed so as to reach that officer not later than 14th May, 1932.

Candidates will be responsible for any expenses which they may incur in attending for interview. 8371

Royal Corps of Naval Constructors.

A COMPETITIVE EXAMINATION for a POST as PROBATIONARY ASSISTANT CONSTRUCTOR will be held at the Royal Naval College, Greenwich, during the first fortnight in July next.

Candidates must not be more than 24 years of age on 1st October next, and must then have been engaged in practical shipbuilding work for at least 18 months. Graduates from the Universities are preferred.

The salaries and other conditions of service are given in full in the regulations of the Royal Corps of Naval Constructors. The salaries during the two or three years' Greenwich course, INCLUDING cost-of-living bonus reckoned at its present rate of 50, are approximately as follow :—

Probationary Assistant Constructors on joining R.N. College, £172 in addition to mess allowance.

Probationary Assistant Constructors during second half of course, £196 in addition to mess allowance.

Candidates successful at the end of the R.N. College course will be admitted into the Royal Corps of Naval Constructors as permanent Civil Servants, with corresponding superannuation and other privileges : the salaries, including bonus as above, of the lower grades being approximately as follows :—

2nd Class Assistant Constructor (first 3 years), £294-£329.

1st Class Assistant Constructor (after 3 years), £399, rising to £668.

The salaries, &c., for the higher grades are stated in the regulations, which may be obtained from the SECRETARY of the ADMIRALTY (C.E. Branch), Whitehall, S.W. 1, to whom intending candidates must submit their names and full particulars of their educational and technical training and practical experience not later than the 30th April.

PRIVATE STUDENTS OF NAVAL ARCHITECTURE.

A QUALIFYING EXAMINATION will be held in conjunction with the above for the admission to the Royal Naval College, Greenwich, of PRIVATE STUDENTS of NAVAL ARCHITECTURE who desire to receive instruction in the course laid down for Probationary Assistant Constructor. Applications for admission as Private Students should reach the SECRETARY of the ADMIRALTY (C.E. Branch), not later than the 30th April.

Private students are required to pay a fee of £50 per session.

Applications for the regulations should be accompanied by an addressed foolscap envelope. 8353

University of Liverpool.

FACULTY OF ENGINEERING.

DEAN : Professor T. B. ABELL, O.B.E., M.Eng., R.C.N.C. (Ret.), M. Inst. N.A.

The University awards the Degrees of B.Eng., M.Eng., D.Eng., Ph.D., and a Certificate and Diploma in Engineering.

Degree Candidates must pass an approved Matriculation Examination. Certificate Candidates must submit evidence of having received a good general education. Diploma Candidates must possess the Certificate in Engineering.

The Courses are designed for students desiring to qualify as MECHANICAL, ELECTRICAL, CIVIL, or MARINE ENGINEERS, as NAVAL ARCHITECTS and METALLURGISTS or METALLURGICAL ENGINEERS. The Courses cover the subjects of examination for Associate Membership of the Institutions of Civil, Mechanical, and Electrical Engineers. The Institutions named, subject to certain conditions, accept the degree of B.Eng. in lieu of part, and in some cases the whole, of the examinations for Associate Membership. The various Departments are housed in commodious and well-equipped buildings, and provide ample facilities for research.

A prospectus of the Faculty, giving particulars of Courses and a large number of Entrance and Post-graduate Scholarships, may be had on application to the undersigned.

8358 EDWARD CAREY, Registrar.

Glamorgan Education Committee.

MINING AND TECHNICAL INSTITUTE AND JUNIOR TECHNICAL DAY SCHOOL (BOYS), NEATH.

WANTED, an ASSISTANT MASTER, possessing a Degree in Engineering of a British University, with works experience in engineering, for service in the Day School and in the Evening Classes.

Salary in accordance with the Burnham (Technical) Award, less 10 per cent.

Forms of application and conditions of appointment can be obtained from the undersigned on receipt of a stamped addressed envelope, and should be returned so as to reach him not later than the 25th April, 1932.

F. E. REES, Director of Education.

County Hall, Cardiff, 2nd April, 1932. 8356

The Engineer

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PUBLIC NOTICES.

City of Kingston-upon-Hull.

CITY ENGINEER'S DEPARTMENT.

The Corporation invite TENDERS for the SUPPLY and INSTALLATION of a GAS-FIRED INCINERATING FURNACE at the Hedon-road Crematorium.

Forms of Tender and other particulars may be obtained from the undersigned.

Firms tendering must give examples of similar installations which have been erected by them.

Tenders, endorsed on cover "Gas-fired Incinerating Furnace," are to be addressed to the Chairman of the Parks and Burial Committee and delivered at the City Engineer's Office before Noon on Friday, the 15th April, 1932.

The lowest or any Tender will not necessarily be accepted.

By Order,
HERBERT HAMER,
City Engineer.

Guildhall, Hull,
31st March, 1932. 8359

County Borough of Sunderland

DEEP WATER QUAY.—CONTRACT NO .6. TO CONTRACTORS.

The Corporation of Sunderland are prepared to receive TENDERS for the SUPPLY and ERECTION of THREE PORTAL QUAY CRANES, one of 5 tons and two of 3 tons working capacity, upon a site on the new Deep Water Quay on the River Wear at Sunderland, County Durham.

The contract documents may be seen upon application to the Engineer for the scheme, Mr. W. H. S. Tripp, M. Inst. C.E., c/o River Wear Commissioners, St. Thomas-street, Sunderland, or may be obtained from him on payment of a deposit of Four Pounds by crossed cheque made payable to "The Corporation of Sunderland," which will be returned on receipt of a bona fide Tender accompanied by the whole of the documents issued.

Tenders, which will only be considered if made upon the form supplied, must be completed in accordance with the detailed instructions incorporated in the documents, enclosed in a sealed cover, endorsed "Tender for Deep Water Quay, Contract No. 6," and delivered at the office of the undersigned, Town Hall, Sunderland, not later than Noon on the 25th April, 1932.

The Corporation do not bind themselves to accept the lowest or any Tender.

H. CRAVEN,
Town Clerk.

Town Hall, Sunderland,
21st March, 1932. 8342

PUBLIC NOTICES.

County Borough of Newport.

TALYBONT RESERVOIR SCHEME. PRELIMINARY ADVERTISEMENT.

The Newport Corporation invite TENDERS from Contractors, skilled in the carrying out of works of a similar character, for the CONSTRUCTION of a large IMPOUNDING RESERVOIR near Talybont, Breconshire.

Plans, &c., can be seen at all reasonable times at the offices of the Engineer, Mr. W. E. Lloyd, M. Inst. C.E., Town Hall, Newport, Mon., from whom full particulars and bill of quantities can be obtained upon the production of the Borough Treasurer's receipt for £100 deposit, which will be returned upon receipt of a bona fide Tender.

The Reservoir is being constructed with the aid of a grant from the Unemployment Grants Committee, and tenders will be required to comply with the conditions laid down under the terms of the grant.

The documents will be available for distribution on the 14th instant, and sealed Tenders, endorsed "Talybont Reservoir," must reach me not later than 10 a.m. on the 5th May, 1932.

The Corporation do not bind themselves to accept the lowest or any Tender.

O. TREHARNE MORGAN,
Town Clerk.

4th April, 1932. 8362

London County Council.

TENDERS are INVITED for the CLEANING and REPAINTING of WANDSWORTH BRIDGE.

Specification, form of Tender, &c., may be obtained on and after Friday, 8th April, 1932, on application to the Chief Engineer, The Old County Hall, Spring-gardens, S.W. 1, upon payment of £1 by crossed cheque or order payable to the London County Council. (NOTE.—CASH WILL NOT BE ACCEPTED.) This amount will be returnable only if a bona fide Tender has been sent in and not subsequently withdrawn. Full particulars of the work may be obtained on personal application and the contract documents may be inspected before payment of the fee.

Remittances by post should be addressed to the CHIEF ENGINEER, The Old County Hall, Spring-gardens, S.W. 1. Personal inquiries at Room 2, No. 3, Warwick House-street, Cockspur-street, S.W. 1.

The contractor will be bound to observe the provisions of a fair wages clause, the terms of which are set out fully in the instructions for Tender and form of contract and in "The London County Council Gazette."

No Tender received by the Clerk of the Council at the County Hall, Westminster Bridge, S.E. 1, after 4 p.m. on Monday, 25th April, 1932, will be considered.

The Council does not bind itself to accept the lowest or any Tender. 8363

PUBLIC NOTICES.

The Galloway Water Power Company.

TENDERS FOR CONTRACT NO. 11. HYDRAULICALLY OPERATED VALVES.

The Galloway Water Power Company invite TENDERS for the SUPPLY, DELIVERY, and ERECTION of THREE 11ft. 6in. diameter BUTTERFLY VALVES with OIL PRESSURE PLANT and ACCESSORIES for their Tongland Power Station.

Copies of the specification and form of Tender may be obtained from their offices on application to the undersigned on or after Monday, April 11th, 1932, on payment of a deposit of Two Guineas for the first copy and of One Guinea for each subsequent copy. Sums paid for any number of copies up to three will be refunded on receipt of a bona fide Tender.

Tenders, on the form supplied, endorsed "Tender for Contract No. 11," must be delivered in duplicate to the offices of the Company not later than Noon on Monday, May 2nd, 1932.

The Company do not bind themselves to accept the lowest or any Tender.

(Signed) T. LAWRIE,
Secretary.

The Galloway Water Power Company,
Queen's House,
Kingsway, London, W.C. 2. 8370

Borough of Torquay.

APPOINTMENT OF BOROUGH ENGINEER AND SURVEYOR.

The Council invite APPLICATIONS for the POSITION of BOROUGH ENGINEER and SURVEYOR, at a salary commencing at £950 a year and rising, subject to approved service, by annual increments of £50 to a maximum of £1100 a year.

Applicants should not be more than 45 years of age and should be Members or Associate Members of the Institution of Civil Engineers or Members of the Institution of Municipal and County Engineers.

No pension or superannuation rights are attached to the office.

A form of application, with a list of duties and general conditions governing the appointment, may be obtained from the undersigned.

Canvassing, either directly or indirectly, will be deemed a disqualification.

HERBERT A. HIELD,
Town Clerk.

Town Hall, Torquay,
Dated April 12th, 1932. 8382

The Bristol Gas Company.

INDUSTRIAL SALESMEN.

There are VACANCIES for TWO TECHNICAL SALESMEN, with practical experience in the application of gas for industrial requirements, to interview and advise consumers.

Applicants should possess an up-to-date knowledge of furnace construction and be able to supervise the installation, adjustment, and maintenance of all types of industrial equipment.

Salary £250 per annum.

Applications, stating age and experience, should be forwarded to the undersigned not later than 16th April.

S. E. HALLIWELL,
Secretary and Commercial Manager.

Chief Offices,
Colston-street, Bristol,
23rd March, 1932. 8355

The Civil Engineers Appointments BOARD, 8, Princes-street, Westminster, S.W. 1, acting under annual licence from the London County Council, invites INQUIRIES from EMPLOYERS SEEKING the SERVICES of PROFESSIONAL ENGINEERS, either as Assistants or in more responsible positions.

All those whose names are accepted for entry in the Board's Register for employment possess qualifications which have been attested by means of scientific examinations, practical training, and experience. P2183

In the Matter of LETTERS PATENT granted to FREDERIK KAREL THEODOR VAN ITERSON and GERARD KUYPERS, dated the 16th August, 1916, and numbered 108,863, for the invention of "Improved Construction of Cooling Towers of Reinforced Concrete."

Notice is Hereby Given that on the 20th April, 1932, an ORIGINATING SUMMONS (1932 V. No. 157) issued out of the High Court of Justice Chancery Division on behalf of GERARD KUYPERS (one of the Patentees) asking that the term of the above-mentioned Letters Patent may be extended for two and a-half years will come before Mr. Justice Luxmoore for directions as to the hearing and any person desirous of being heard in opposition must at least seven days before that date lodge Notice of Opposition (giving an address for service within the United Kingdom) at Room 17a Royal Courts of Justice Strand, London, and serve a copy thereof upon the undermentioned Solicitor and upon the Solicitor to the Board of Trade.

Dated this 17th day of March, 1932.

GEORGE BELOE ELLIS,
70 and 72, Chancery-lane, London, W.C. 2,
upon whom all documents requiring service should be served. 8360

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The Engineer

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Entered as second-class matter at the Post Office, New York, N.Y., December 12th, 1896, under the Act of March 3rd, 1879 (Section 397, P.L. & R.)

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"THE METALLURGIST."

This Supplement, which deals with the Science and Practice of Metallurgy, both ferrous and non-ferrous, is published free with the last issue of THE ENGINEER in each calendar month.

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The charge for Classified Advertisements is 1/- per line up to one inch—minimum charge 4/-; those occupying one inch or more at the rate of 12/- per inch. Orders must be accompanied by a remittance. The rates for Displayed Advertisements will be forwarded on application. Classified Advertisements cannot be inserted unless delivered before TWO o'clock on Thursday afternoon (the day before publication).

Letters relating to the Advertisement and the Publishing Department of the Paper are to be addressed to the Publisher, all other letters are to be addressed to the Editor of THE ENGINEER.

THE ENGINEER DIRECTORY.

This Directory, which is published annually in the interests of advertisers in THE ENGINEER, may be obtained free of charge on application to the Publisher.

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SITUATIONS OPEN.

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TO ADVERTISERS UNDER BOX NUMBERS IN THIS CLASSIFICATION.

For the benefit of applicants, the Proprietors are prepared to insert brief notices that vacancies are filled, upon receipt of notifications from the Advertisers. These notices (limited to one line) will be free of charge and co-operation is asked for.

WANTED, Capable DRAUGHTSMAN, with Experience in Water Filtration and Softening Plant. Eastern Counties district. State experience, age, and salary required.—Address, 8354, The Engineer Office. 8354 A

WANTED, REPRESENTATIVE, London District, by well-known Structural Engineers. Must be well connected. Write in confidence; give fullest particulars and terms.—Address, 8384, The Engineer Office. 8384 A

WANTED, Thoroughly Competent MAN, to Take Charge of Engineering Works Production. Must have had first-class experience in economic production and lay-out of plant. Age about 40. Excellent prospects.

Apply, giving fullest information of experience, stating age and salary required, to ENGINEER, c/o Wykes and Co., Chartered Accountants, 24, Friar-lane, Leicester. None but first-class men need apply. 8367 A

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Address, 8386, The Engineer Office. 8386 A

CHIEF ENGINEER REQUIRED at Large West End establishment. Must have thorough knowledge of Electrical, Refrigerating, and Steam Plants.

Write, giving age and full particulars of experience, together with salary required, to C. E. R., Box 151A c/o Smith's, 3, Lincoln's Inn-fields, London, W.C. 2. 8385 A

ENGINEER REPRESENTATIVE, Young, WANTED by Firm of Laundry and General Engineers. Give particulars of experience, list of employers and positions held.—State age and salary to Box B.188, T. B. Browne's Advertising Offices, 163, Queen Victoria-street, London, E.C. 4. 8377 A

LUBRICATING OIL FIRM, Old Established, medium size, REQUIRE TRAVELLER, age 25/35; S. London. Experience not necessary. Personality and drive essential. Salary and commission.—Address, P2278, The Engineer Office. P2278 A

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ADVERTISER, Having 20 Years' Experience of India (Northern, Calcutta, and Bombay), during which orders worth upwards of a million pounds have passed through his hands, for structural steel, railway material, metals, machinery, electrical plant, engineers' hardware, &c., DESIRES RESPONSIBLE POSITION in England where his extensive knowledge of commercial engineering in the East would be of value.

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ENGLAND—SWEDEN.

Lt.-Col. R. Jobson,

Varberg, Sweden, age 54, M.I.E.E., M. Iron and Steel Inst., M. Inst. Petr. Techn., British subject by birth, born in Sweden and speaking Swedish fluently, experienced organiser and engineer,

DESIRES COMMERCIAL OR TECHNICAL POST

with large Corporation in England or Sweden; British, Swedish, and German references. Will visit England for interview. 8378 B

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For continuation of Small Advertisements see page 4.

A Seven-Day Journal

French Air Services.

SINCE the beginning of 1920 France has spent 12,000 million francs on the air services, and while, in the number of machines employed, that country probably takes the lead, the efficiency of the aircraft was severely criticised when the Budget Estimates were discussed by the Senate last week. It was complained that the Air Minister had ordered machines indiscriminately without taking into account the progress made by other countries in the technical development of aviation. Now that the Air Ministry has been suppressed, the technical branch of the service is to be organised on much more extensive lines in association with the universities and schools. For the nine months of the present year covered by the Budget, the amount voted for research work and for the creation of aircraft types is 114,695,000f., and the total amount is 1,914,633,000f., which, compared with the previous Estimates for the whole of 1931, represents an increase of 351,554,000f. More is also to be done for civil aviation which has fallen short of expectations, and, in the case of the South American service, was financially disastrous. This latter experience appears to have shown the futility of any single country striving for a monopoly of international traffic, and the object of the French now is to place civil aviation on a level with that of other countries, so that it can work in co-operation with them as is being done with Belgium in organising air communication with Central Africa. The method of State participation in civil air services has not yet been definitely settled upon, though the Senate advocates the system adopted in the case of the company working with a similar Belgian company for the African air lines. The State contributes 33 per cent. of the capital of the French company, and has absolute control over its operations. This amounts to a State working of air lines, which is not meeting with general approval.

Salesmanship.

SPEAKING at the Bristol branch of the Incorporated Sales Managers' Association on Friday last, Sir Francis Goodenough pursued his campaign for improved salesmanship with his customary vigour. He combatted the view that public reproof of British merchants and manufacturers was undesirable, as it was "calculated to advantage our competitors and discourage our own people." Nothing, he said, that our foreign rivals did not already know was revealed by discussion of British methods, and he supported that statement by extracts from numerous cummunications he had received from foreign centres. British exporters had been urged by privately given advice for years past to improve their methods, but as there were still many recalcitrants, the only thing was to shout the facts from the housetops, for the fight for the markets was of "vital importance." "If," he said, "we fail to increase the volume of our export trade from that to which it has fallen, it will become absolutely impossible to maintain in reasonable comfort, if we can maintain at all, the present population of these islands. . . . Instead of being a prosperous, progressive, and powerful nation, we shall sink into poverty and obscurity, and cease to be the leader of the civilised world." The Essentials to Victory involved, he said, the resolution by every firm to apply to the problems of finding, developing, and maintaining markets at least as much time, thought, and energy, and fully as high a degree of ability as are applied to the problems of production and finance. Thoughtful and skilful recruitment of the selling branches of business was necessary, and the prospects and status should be such as would attract men possessing the "highest qualities of character and intellect."

Preservation of Historic Locomotives.

THE L.M.S. Railway announces that two of the company's most historic locomotives, the London and North-Western Railway Company's "Hardwicke" and the Caledonian Railway Company's "No. 123," are not to be broken up, and that consideration is being given to the best means of preserving them. The "Hardwicke"—L.M.S. "No. 5031"—belongs to the "Precedent" class 2–4–0 locomotives. "Hardwicke" was designed by the late Mr. F. W. Webb with others of this famous type for working express passenger trains over the West Coast route between Euston and Carlisle, and was constructed at the London and North-Western Railway's works at Crewe in 1892. She differed from the original engines of the "Precedent" series in that the boiler pressure was raised to 150 lb. per square inch, while the driving wheels were increased in diameter from 6ft. 7½in. to 6ft. 9in. The most notable performance achieved by this locomotive was recorded during the "Race to Aberdeen" in 1895, when "Hardwicke" drew a West Coast express from Crewe to Carlisle, 141 miles, in 126 minutes, at an average speed of 67·2 m.p.h., over a route which includes the 4½ miles' ascent of Shap at 1 in 75. The total mileage run by "Hardwicke" up to the time of her withdrawal from service on January 30th last was 1,326,470 miles. The other historic locomotive, the Caledonian "No. 123," is a 4–2–2 L.M.S. "No. 14010," which is still in service on passenger trains between Perth and Dundee and which has run over 40,000 miles during the past two years. This engine has the distinction of being the only single driving wheels locomotive remaining in regular passenger service in Great Britain. She was built by Neilson and Co., of Glasgow, in 1886 for the Edinburgh Exhibition, and was acquired by the Caledonian Railway. During the "Race to Edinburgh" in 1888 she accomplished several notable performances with West Coast expresses over the difficult stretch of steeply graded railway between Carlisle and Edinburgh, which includes the ascent of Beattock Bank. Her best recorded feat, with a four-coach train, was to cover the 100¾ miles in 102½ minutes at an average speed of approximately 59 miles per hour.

Rural Reconstruction Association.

AT the annual meeting of the Rural Reconstruction Association, held in London last Saturday, April 2nd, Mr. R. Borlase Matthews referred to the important part which electrification must play in the revival of rural England. The possibilities for development were enormous. At present, he said, only 4000 out of a total of 418,000 farms in this country were using electricity. That was due in the main to the fact that supplies were not yet available in the majority of rural areas. He hoped, however, that with the development of the Central Electricity Board scheme rapid progress would be made. He appealed to all landowners and others associated and interested in the countryside not to put up unnecessary obstacles in the way of the erection of overhead lines, and went on to state that in the majority of cases a supply could not be given to a scattered community at a reasonable price unless it was done by means of overhead lines, the cost of underground cables in such cases being prohibitive. He did not consider that a prairie system of farming could ever be successful in this country, with its low labour cost and low productivity per acre. What we needed was not less, but more, intensive cultivation, for we had the markets, we had the labour, and we had the ability, while the area of land available was limited. For that purpose extensive use would have to be made of electricity. It might also be necessary to reconsider many of the present-day accepted methods of working. Specialisation of duties would undoubtedly bring the farm more into line with a factory, and thus increase the output per head of labour employed and generally improve the standard of efficiency of the farm. The farms of the future would have to be much more scientifically organised than those of the present.

Sir Charles Wright and British Industry.

AT the general meeting of Baldwins, Ltd., during the past week, Colonel Sir Charles Wright, the chairman of the company, gave figures illustrating the depths of the depression from which the heavy engineering industries are emerging. Some of these figures will be familiar to our readers. The production of British pig iron last year was only 3,758,000 tons, compared with 7,590,000 tons in 1929, and represented only one-third of the productive capacity of the country. Steel production fell from 9,636,000 tons to 5,179,000 tons, whilst imports, at 2,852,000 tons, exceeded exports by 871,000 tons. In 1913 the output of coal from the mines was 287 million tons compared with 220 million tons last year. With reference to that industry, Sir Charles Wright considered that the question of hours ought to receive immediate attention. According to present arrangements the miners would automatically revert to the seven-hour day next July, and in his opinion such a change would mean irretrievable disaster to the industry. The production of tin-plate in this country, exclusive of terne and black plates, amounted to 780,182 tons in 1929 and 648,597 tons in 1931, a reduction of 17 per cent. The average price of the basis tin box fell from 18s. 4½d. to 14s. 4½d. in the same period, a reduction of 22 per cent. Of the total British production 40 per cent. went to home consumers, 19 per cent. to the British Empire, and 41 per cent. to other markets. The pooling system which regulated prices and outputs terminated last June, and prices became unremunerative. Efforts, however, had been successfully made to bring the trade together again, and a system of pooling in conjunction with a minimum price had been arranged.

Interference with Aircraft Wreckage.

THE Air Ministry desires to call the attention of the general public to the great difficulties which have sometimes been caused by private persons thoughtlessly removing parts of damaged aircraft. It is of the greatest importance that the causes of accidents to aircraft should be ascertained. Whenever a serious accident is reported the Air Ministry Inspector of Accidents proceeds with the least possible delay to the scene of the accident to examine the crashed machine, and it is essential for his purposes that the wreckage should not have been disturbed more than is necessary to set the occupants free and to prevent any immediate risk of damage to persons or property. During the interval, therefore, before the arrival of the Inspector, members of the public are earnestly requested to abstain from any interference with a wrecked aircraft, except for these emergency purposes. The police already have instructions on the whole matter, and interference with wreckage is definitely prohibited by law. A further point of great importance is that broken pieces of the aircraft—for example, a part of a propeller—may be found some distance away. It will be of the utmost assistance if the finding of such pieces is immediately reported to the police, or to the Inspector of Accidents. Although breaches of the law have occurred, the Air Ministry feels sure that no one would wish to retain a broken part of an aircraft in these circumstances for whatever purpose, even though it is an apparently insignificant item, once it has been pointed out that it may be essential to the authorities for tracing the cause of the accident. In a recent case a broadcast appeal for missing parts was made, and three members of the public went to much trouble in reporting the finding of certain bits of metal. This enabled the Air Ministry to establish the cause of the accident in question beyond doubt.

The Machine Tool Trades Association.

FROM the annual report of the Machine Tool Trades Association we learn that during 1931 ten firms withdrew from membership and that three joined the Association. The membership now stands at 102. Under normal conditions the Association's quadrennial exhibition would have been held at Olympia, London, during the autumn of this year. Last August, however, in response to inquiries, a very large majority of the members expressed themselves in favour of postponing the exhibition. The question has been debated at considerable length since that date and, we gather, there has been a certain amount of difference of opinion on some of its aspects. Some members, while agreeing to the postponement, were in favour of holding the exhibition in 1933. Others urged that if no exhibition was to be held this year members should be free to exhibit their products at any exhibition before the next one to be organised by the Association. As the outcome of much discussion it has now been decided that the next exhibition is to be held in November, 1934. As a condition of retaining their membership of the Association the members are required to sign a bond by which they agree not to exhibit their products—except in certain approved instances—until the 1934 exhibition.

The Irak Pipe Line.

IN a Journal note of February 6th, 1931, we referred to the convention between the Palestine Government and the Irak Petroleum Company, Ltd., for the construction of a pipe line through Palestine to the port of Haifa in Acre Bay. This pipe line forms part of a larger scheme for the laying of a pipe line from Kirkuk in Irak to Haditha, where it will fork, one section being carried through the British mandated territory of Palestine to Haifa, and the other through the French mandated territory of Syria to the port of Tripolis. Early this week the announcement was made that Stewarts and Lloyds, Ltd., had secured the contract for the supply of 60,000 tons of steel tubes, representing a value of over £500,000. It is understood that other portions of the contract for the supply of steel tubes will be allocated to French, German, and, possibly, American firms. Meanwhile, further orders have been placed with Redpath, Brown and Co., Ltd., for sixty-three steel buildings, including garages, bungalows, and a hospital, for the pipe line route, and also with both British and French firms for the supply of motor transport vehicles. The total cost of the whole pipe line scheme, which is to be completed in 1935, is estimated at over £10,000,000.

The Port of Manchester.

ACCORDING to a report issued by the Manchester Ship Canal Company, the trade of the Port of Manchester showed some improvement on the first quarter of the year just ended, and the adjusted figures will exceed those of the corresponding months of 1931. It is pointed out that the trade increase in the earlier part of the period was not wholly due to traders anxious to anticipate new import duties, as the traffic improvement was mainly in duty-free merchandise. Australian and New Zealand cargoes improved, and raw cotton traffic was more than maintained. Outward shipments of fine goods, particularly to the Persian Gulf, improved. Oil imports showed an upward tendency, and one tanker, the "Harry S. Seidel," discharged 12,500 tons of motor spirit at the Stanlow Oil Port. The traffic at this port is now second only to that of London, and the docking facilities are being considerably extended by the building of a new oil dock. Another noteworthy improvement is the new 600ft. lay-bye for the Irlam works of the Lancashire Steel Corporation, which is being equipped with the most modern ore-discharging plant. Recent direct sailings of Manchester liners include those to Montreal and Quebec, following the opening of the St. Lawrence, while improvements in Baltic trade are also expected now that the open water season has begun.

Sydney Harbour Bridge.

No. IV.*

Design of the Arch Span Trusses.

As is usual in arch trusses erected by the cantilever process, the web bracing of the arch span trusses is of the N type, a formation which facilitates the placing of the members in position. The number of panels is even—that is to say, the trusses are symmetrical about the centre. In this respect the Sydney arch differs from that at Hell Gate, New York, the largest arch previously built. In that case the number of panels is odd, the central panel having two crossed diagonals, one of which is redundant. The use of an even number of panels for the Sydney arch was dictated by the process of erection involving the building of the arch from both sides, until the half-arches met at the centre. In addition, in the designer's opinion, an arch with an even number of panels is technically preferable to, and more economical and of better appearance than, one with an odd number of panels.

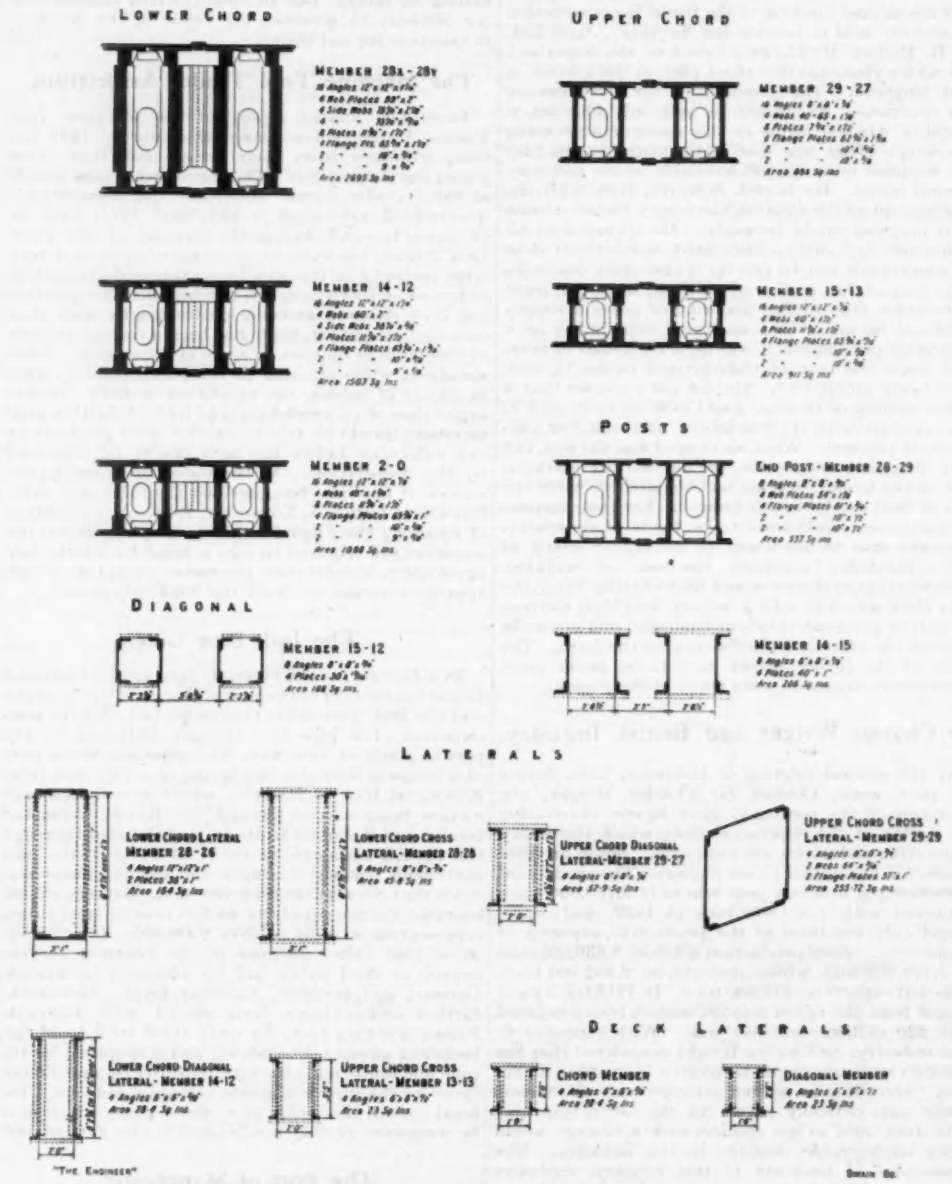

Lower Chord
Member 28x - 28y
Upper Chord
Member 29 - 27
Member 14 - 12
Member 15 - 13
Posts
Member 2 - 0
End Post - Member 28 - 29
Diagonal
Member 15 - 12
Member 14 - 15
Laterals
Lower Chord Lateral Member 28 - 26
Lower Chord Cross Lateral - Member 28-28
Upper Chord Diagonal Lateral - Member 29-27
Upper Chord Cross Lateral - Member 29-29
Deck Laterals
Lower Chord Diagonal Lateral - Member 14-12
Upper Chord Cross Lateral - Member 13-13
Chord Member
Diagonal Member
"The Engineer"

Fig. 22—Typical Cross Sections of Arch Span Members

Arch Members.—Typical cross sections of members of the arch are given in Fig. 22. The chords, posts, and diagonals of the trusses are all of four-web construction. In the chord members each web forms with four angles an I section. These four I sections are connected in pairs by solid flange plates to form two box sections, which, in turn, are joined together by double longitudinal covers, which connect the flange plates along the centre line of the member. Inside each compartment the angles and webs are separated by packing strips 1½in. thick. At the chord joints these strips are replaced by the main gusset plates. The fact that the members were divided longitudinally permitted them to be erected half-by-half, and effected a corresponding reduction in the capacity of the shop and field lifting equipment.

Throughout the bottom chords and to the extent of about 50 per cent. of the top chords, the principal angles are of 12in. by 12in. by 1½in. section. These angles were rolled in lengths up to 66ft. at Messrs. Dorman, Long's Britannia Works. When they were first produced for the Sydney Bridge contract, these angles were nearly twice as heavy as the heaviest section previously rolled. They have, we are informed, since been found of great service in other structures—both bridge and building—of a lighter character than Sydney Harbour Bridge. The use of these heavy angles was dictated by the necessity for maintaining a proper proportion between the elements composing the chord members and for providing an effective connection between the flange and the web materials. In addition, their use facilitated the detail design of the joints and splices in the members. Rolling mill problems were also involved in the production of the web and flange plates for the chord members. These plates, of the special silicon steel, had to be provided in thicknesses up to 2¼in. and in widths up to 8ft. 3in.

The section of the chord members is considerably greater than that of any member of any bridge previously constructed. The members of the lower chord are by far the heaviest in the whole structure. The lower chord varies in depth from 4ft. at the centre of the span to 8ft. 3in. at the bearings. On each side of the span centre four members of the lower chord are of the minimum depth. Thereafter, the depth increases from member to member to the maximum depth at the bearings. This increase of depth is required in order to provide the necessary increase in the sectional area of the members towards the ends of the span. Further increase of that area is obtained by the addition of side plates to the webs between the principal angles and by an increase in the thickness of the flange plates. The web plates are 2in. thick in all the members of the lower chord, except in those members adjacent to the centre of the span. In all the members transverse plated stiffening diaphragms are fixed on each side of all the joints and connections. In addition to the longitudinal joint dividing them in halves, the members are subdivided in the transverse direction by splices in order to reduce their weight for handling purposes, and in some cases for the purpose of reducing their length. This splicing applies to member 28–26—the member of the lower chord next to the main bearing—which is divided into three sections, and to the succeeding members up to 20–18, all of which are divided into two sections.†

Unlike the lower chord, the top chord is of constant depth throughout—3ft. 4in. over the angles—except in the case of the end member 29–27, which, at point 29, is increased in depth to accommodate the anchorage pin used during the erection process. The construction of the top chord members is in general similar to that of the lower chord members. Variation in the section is obtained by a change in the thickness of the webs and flanges, by the addition of side webs and by a change in the principal angles from 12in. by 12in. near the crown to the arch, to 8in. by 8in. near the end posts.

The end posts are similar in construction to the upper and lower chord members, except in so far that each of the webs is secured to the flange plates by two angles instead of four, both angles being external to the box sectioned compartments. The rest of the posts are composed of four web plates, each carrying two angles turned outwards. The webs are joined in pairs by double angle lacing, and the two compartments so formed are united by heavy tie plates at the ends and centre of the member and at the intermediate splices. Over the three panels next to the end posts at each side, the cross girders supporting the deck are connected directly to the posts of these three panels. Beyond point 22 the deck is suspended by means of hangers from the lower chord. The posts of the three panels referred to are stayed in the plane of the trusses by longitudinal members connected to panel point 22 and lying immediately beneath the cross girders of the deck.

The truss diagonals are built up in two sections similar to the posts, but have their angles turned inwards instead of outwards. In addition, the webs of each compartment are joined by a single lacing of flat bars, and the two compartments are, for the most part, connected by tie plates at the ends only of the members. Near the centre of the span the diagonals, acting in compression, are provided with central as well as end tie plates.

Characteristic Arch Truss Connections.

In our four-page Supplement, we illustrate the design of characteristic connections of the principal members of the arch trusses.

Connection 28.—This connection illustrated in Fig. 14 in the Supplement, forms the end of the structural framework of the arch and joins on to the upper forged steel saddle of the main bearing. A view of the member taken while its bearing surfaces were being machined in the shops, is reproduced in Fig. 23. The four webs of the chord are thickened by the addition of side plates, which provide a bearing area on the saddle sufficiently large to reduce the bearing pressure to the limit of intensity permitted. The webs by means of these side plates are increased in thickness to 10in. In order to ensure the effective riveting of this great thickness, rivets 1¼in. in diameter were used. These rivets are the largest employed on the work. In addition to these side plates the webs at the main bearing end are reinforced by means of longitudinal diaphragms, one in each compartment, consisting of 12in. by 12in. angles united by double 1¼in. plates. The ends of the diaphragms in the two outer compartments are machined, together with the ends of the web plates, to take a bearing on the top saddle of the main bearing—see Fig. 23. The end of the member and the saddle are connected by 2in. fitted bolts passing through the web plates and through flanges formed on the back of the saddle forging. The end posts are connected to the chord members in the manner previously indicated, namely, by means of gusset plates passing through slots in the top flanges of the chord members and extending to the full depth of the chord. The gussets replace, as already noted, the packing strips inserted between the flange angles and webs on the inner sides of the compartments. At this point the gussets are 2in. thick, as compared with the standard 1¼in. elsewhere.

Connection 29.—This connection illustrated in Fig. 16 in the Supplement, forms the junction between the end of the upper chord and the end post. It is of a special design, because of the provision which had to be made for the attachment of the anchorage ropes to this point during the erection of the bridge. In Fig. 17 the anchorage details at this point are illustrated. These details will be described fully in a subsequent article. The normal depth of the top chord is 3ft. 4in., but at connection 29 it is increased to 5ft. 5in. for the purpose of accommodating the 27in. diameter anchorage pins. To provide the requisite bearing area for these pins the webs are increased in thickness by the addition of side plates. On completion of erection the anchorage pins were withdrawn and the holes closed by cover plates. At this point the gusset plates connecting the end posts and diagonals to the chord stop on the underside of the chord member and do not, as in the normal case, extend through that member to the opposite flange. The reason for this departure from the normal lay in the fact that the method of erection made it necessary to provide an effective tension connection for both flanges of the top member of the end post portal, a fact which rendered it impracticable to extend the main gussets through the lower flange of

* No. III. appeared April 1st.

† See Fig. 3 in our issue of March 18th for a key to the numbering of the truss members.

the chord. The top member of the portal bracing is rhomboid in section with vertical sides and with its top and bottom flanges in the planes of the flanges of the chord member. It is joined to the chord by means of gusset plates fixed to both flanges and to the end posts by vertical portal gussets.

Connection 22.—This connection—see Fig. 15 in the Supplement and also Fig. 24 herewith—occurs at the point at which the line of the deck cuts the lower chord. The cross girder for the deck is connected to the post 23–22 situated directly over this connection and is of less than the normal depth in order to conform with the required level of the deck at this point. The lateral bracing system of the deck intersects the lateral bracing system between the two lower chords at a height of 8ft. 6in. above panel point 22. Above this height the lateral bracing system between the two lower chords is omitted until a level is reached which is sufficient to provide the necessary head room for the rail and road traffic passing between the trusses. This detail of the design will be made clear by reference to the sixth view reproduced in the Supplement published with our issue of March 18th. Over this laterally unbraced portion the lateral forces on the lower chords are taken only by the resistance to bending of the chord members themselves. The deck lateral bracing system—to be dealt with more fully later on—transmits its reaction to the lateral bracing system of the lower chords through struts which are pin-connected to brackets on the outside faces of the chord members. By this means a certain amount of relative distortion is permitted between the two bracing systems. At a point between panel point 22 and the underside of the deck the two lower chords are connected by a braced girder lying in the plane of the chord members. In order that they may clear the flange of this girder the deck stringers are reduced in depth in its vicinity. From the underside of the deck stringers at panel point 20 inclined members extend to panel point 22 to convey longitudinal forces—such as those arising from the braking of the trains—from the deck into the arch trusses. The member, already referred to, which, lying just beneath the deck cross girders, braces together the posts of the three panels next the shore, is connected between the two inner gussets at the foot of the post and diagonal immediately above panel point 22. This bracing member and its connection are clearly seen in Fig. 24.

Connection 12.—This connection, Fig. 18, is typical of all the joints in the lower chord between panel points 22 north and south with the exception of the joint at the centre of the chord. The main gusset plates, four in number, extend through the top and bottom flanges of the chord members, the flanges being slotted to permit their passage and the 1¼in. packing pieces behind the main angles being omitted in way of the gussets. The post, diagonal and hanger are connected to the gussets entirely outside the planes of the chord flanges. The foot of the post

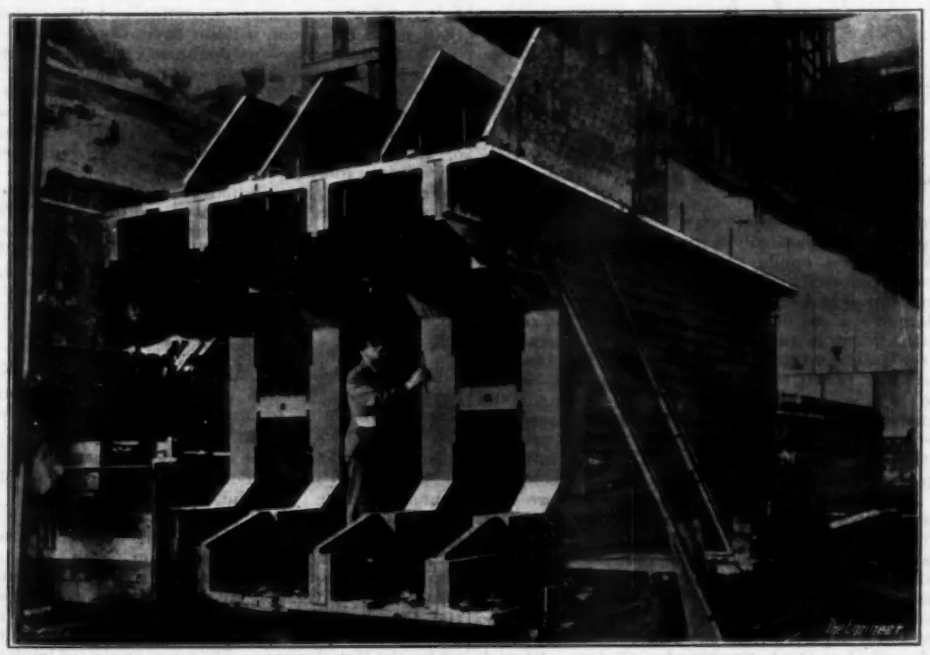


FIG. 23—END OF LOWER CHORD BEING MACHINED IN WALL PLANER

connects with the outside faces of the two pairs of gussets and the foot of the diagonal with the inside faces. On the underside of the chord the deck hanger is supported from two diaphragms, each lying between a pair of the gussets. The load received from the hanger is therefore transmitted uniformly through all four plates. Cover plates with bevelled edges are applied to the legs of the 12in. by 12in. angles of the chord members. On the vertical legs these cover plates extend sufficiently far to lap over the joint between the gusset plates and the packing pieces inserted between the angles and the chord webs. Cover plates are also applied to both sides of each of the four webs and to the outside faces of the chord flanges. The flange covers are interrupted for the passage of the main gussets. The lateral cross and diagonal members are connected to the chord members by means of lateral gusset plates joined to the top and bottom flanges of the chord. These lateral gussets extend beyond the main gusset slots in the chord flanges in order that transverse stresses may be transmitted from the lateral bracing system to the chord flanges without reliance being placed entirely on the heads of the rivets which hold the main angles to the chord webs.

Connection 13.—This connection, Fig. 19, is representative of all the joints in the top chord except those at the end posts and at the centre of the arch. Its features are similar to those of connection 12, except in so far as the upper flange does not need to be slotted for the passage of the main gusset plates. The upper lateral gusset and the top flange covers are scarfed or inclined at their edges to facilitiate the movement of the creeper crane bogies over them.

Connection 0.—At this connection, Fig. 20, which occurs at the centre of the lower chord, first contact between the two half arches was made during the erection process. The connection was therefore primarily designed to meet the special circumstances arising from that fact. The main gussets are arranged in the normal way to pass through the flanges of the chord members for the purpose of providing attachments for the posts, diagonals, and deck hangers. They differ, however, from the normal in so far that each gusset is divided vertically, each half being united to the corresponding chord member. Each chord member ends with a rectangular recess, into which are fitted two forged steel saddles each measuring 4ft. 2in. by 2ft. by 1ft. 2in. and bearing on two of the chord webs. These saddles provide seatings for two forged steel pins, 8in. in diameter and 4ft. 1in. long. The pins form a permanent part of the arch structure. The use of two pins instead of one was dictated by the necessity for providing a passage for the pilot pin employed to guide the two half arches into correct alignment during the closing of the arch. The top and bottom flanges of the abutting chord members are not united by cover plates, as they are at other connections. Light final covers to keep out rain are applied over the joints, but otherwise the flanges are not directly connected. The main gusset plates are, however, directly connected at the joint. Above the chord the connection between them is provided by the post which, although erected in halves, was subsequently spliced into a single unit. Below the chord the gusset halves are joined by cover plates. Additional union at the joint is provided by cover plates applied across the division in the lateral gusset plates. To facilitate the erection of the transverse member of the lateral bracing a recess was formed in the lower lateral gusset. After the member had been lifted into position the recess was closed by a plate. The post 0–1 for purposes of erection was divided vertically, the halves being attached to the separate half arches. After the lower chord had been closed and the correct amount of compression had been applied by means of jacks to the upper chord the halves of the posts were united by cover plates.

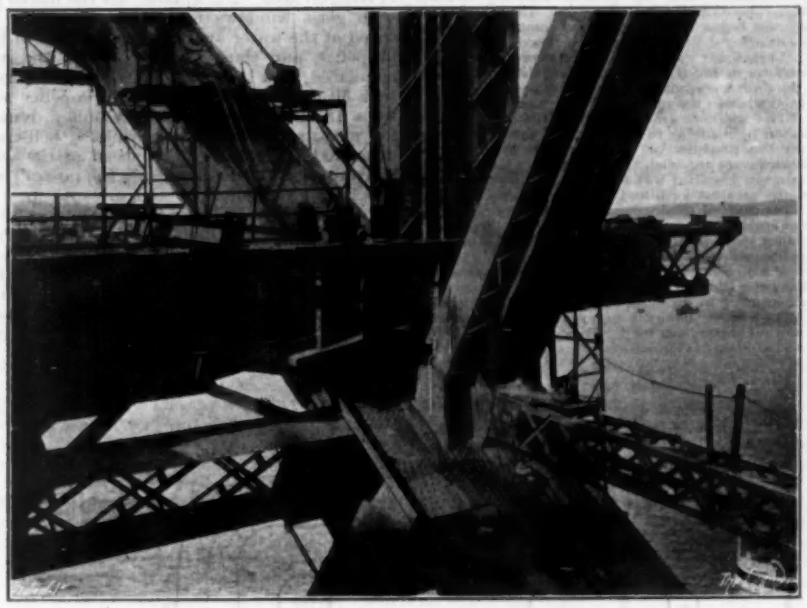


FIG. 24—LOWER CHORD JOINT 22

Connection 1.—This connection, Fig. 21, was specially designed to permit the carrying out of the operation of stressing the upper chord. The chord members of the two half arches abut against each other through 10in. diameter forged steel pins resting in saddles which bear against the chord webs. As at connection 0, the vertical and lateral gussets are connected across the joint, but there is no connection for strength purposes across the joints in the chord flanges. The top lateral gusset is recessed to permit the transverse lateral bracing member to be lowered into position, the recess subsequently being filled and covered.

(To be continued.)

BRITISH STANDARDS INSTITUTION.

All British Standard Specifications can be obtained from the Publications Department of the Institution at 28, Victoria-street, London, S.W. 1. The price of each specification is 2s. 2d. post free, unless otherwise stated.

TERMINALS FOR ELECTRICAL APPARATUS USED FOR RAILWAY SIGNALLING.

No. 442—1932.—This is the first of a series of B.S. Specifications relating to railway signalling apparatus. It has been found possible to restrict the number of sizes of terminals to two, thereby greatly simplifying the work of the linesman in making adjustments on site. A special design of terminal has been standardised with a view to facilitating the attachment and removal of wires from terminals in awkward positions. The dimensions and the standard assembly of the various component parts are specified.

VOLTAGES FOR NEW SYSTEMS AND INSTALLATIONS.

No. 77—1932.—This is a revision. As regards low voltages, no alteration to the existing standards has been made, but as regards high voltages the number of standard voltages has been somewhat reduced, and special provision has been made for the requirements of the high-voltage inter-connected networks of the Central Electricity Board. A special recommendation is made with regard to the voltage to be adopted for rural electrification schemes. Price 1s. 2d. post free.

Institution of Naval Architects.

No. IV. (*conclusion*).*

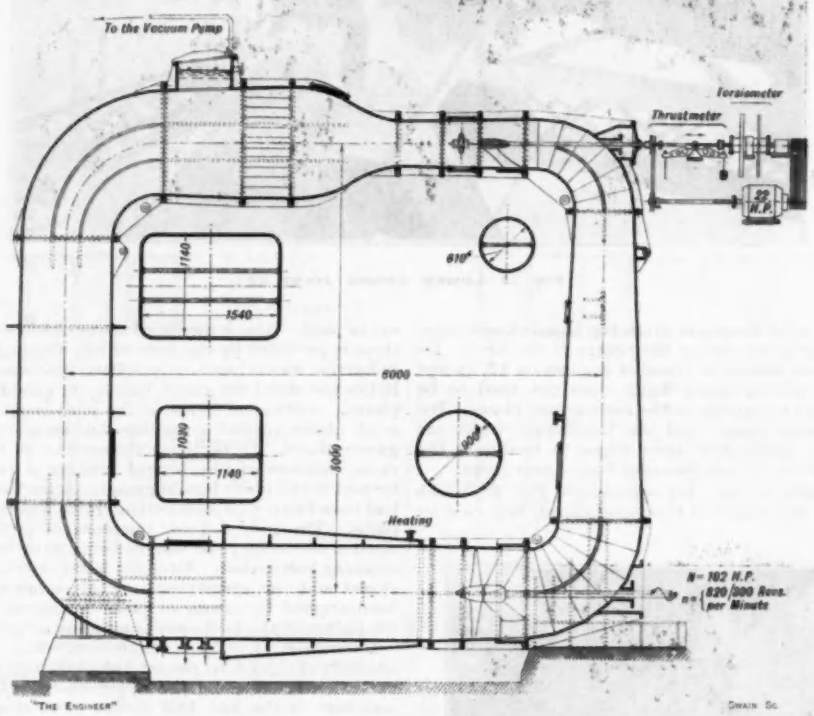
Propeller Cavitation.

The second paper read on Thursday afternoon was entitled "Cavitation Experiments on a Model Propeller," and was presented by Dr. G. Kempf. In what follows we give a short summary of its contents.

The paper describes the closed water tunnel illustrated herewith, which has been built at the Hamburg Experimental Tank in order to investigate the problems of propeller cavitation, which are associated with the present tendency towards ships with higher speeds and increased powers. The construction of the tunnel was begun in 1929, and was completed in May, 1931. As the drawing shows, it is built as a closed circuit standing upright. In its lower part there is a screw propeller, driven by an electromotor of 102 H.P., which impels the flow. In the upper part the flow is contracted by a nozzle and is led to the cylindrical tube wherein the model propeller works which is to be tested. Glass windows are arranged in the walls so that observations can be made as to the flow and the extension of cavitation on the propeller or on other objects. Different tubes for measuring are provided. The diameter of the tube used for the experiment described was 400 mm., and measurements showed that the greatest local and time oscillations were not more than 1 per cent. of the average speed of the flow, which was to be kept constant.

The maximum speed attainable in the tube is 12·5 m./sec., but the experiments were made throughout with a constant speed of flow of 6 m./sec. The pressure is lowered by a vacuum pump, and the water can also be heated.

For the experiment in question the model of the propeller of a fast liner of 5 m. in diameter on a scale of one-twentieth, i.e., of 250 mm. diameter, was used. Former experiments had



CLOSED WATER TUNNEL FOR PROPELLER CAVITATION EXPERIMENTS

been made with a model one-thirtieth of the same screw in the isolated condition, and on the self-propelled ship model in the open tank with atmospheric pressure up to a corresponding speed of 30 knots. By these experiments the revolutions, the necessary thrust, and the shaft horse-power for every speed had been obtained under Froude's law. It was desired to find out what alteration of revolutions and power on the real propeller of the ship might be expected under cavitation. In the normal model tests made by the Froude method the normal atmospheric pressure lies over the propeller, and, therefore, the absolute pressure on the model propeller is too great compared with the pressure on the ship's propeller. From the self-propelled model tests the slip, the thrust, and the shaft horse-power for every corresponding speed of the ship are calculated according to the pressure on the model.

The question was, therefore, how would revolutions and power increase if the model propeller had to deliver the same thrust at the reduced pressure made to correspond to the existing pressure on the ship's screw? It may be assumed that the thrust, being calculated for a certain speed in the normal way from the self-propelled model test, will not be changed by cavitation on the propeller. The experiments were conducted in the following manner:—The flow, i.e., the speed of advance v, was kept constant during all the trials, and the revolutions n were altered. To each number of revolutions there thus belongs a certain advance-constant $\lambda = \frac{v}{n \cdot D}$. The pressure was regulated so that for the uppermost point of the tip circle of the blades the relation of the static pressure to the hydrodynamic pressure of the entrance speed on the model propeller was exactly the same as in the ship's propeller. This was realised step by step for speeds of 27, 28, 29 and 30 knots. The difficulty of the real entrance speed being neither constant nor known is easily overcome, if, instead of it, the speed of advance is introduced which remains in the same relation to the entrance speed at the same advance-constant or slip-ratio for ship and for model. Then under each of these conditions the number of revolutions, the thrust and the torque of the propeller are measured in the usual manner.

The model propeller—scale 1/20—was measured throughout at a constant speed of flow of 6 m./sec. for different advance-constants, or slip-ratios, first with atmospheric pressure. The measurements were taken under the same conditions of pressure as those under which formerly the model propeller—scale 1/30—had been tested in the open tank in the isolated condition and behind the self-propelled model.

The results obtained in the cavitation tunnel and in the open tank are marked by close agreement, which indicates that the cavitation tunnel method can be utilised to obtain reliable results. The paper is accompanied by curves and tables relating to the results obtained, and it concludes with a useful bibliography of the available literature on cavitation in relation to screw propulsion.

Mr. S. S. Cook said it was not well known that Sir Charles Parsons constructed at Wallsend a large size vacuum tank for testing propellers and further exploring the phenomenon of cavitation. That tank was built in 1910 in the form of a tunnel 3ft. in diameter of circular section, arranged in a closed oval circuit of a total length of 60ft. It consisted of an upper and a lower horizontal limb joined together by ends lying at about 45 deg. from the vertical. In the upper horizontal portion was inserted a section of reduced area—2ft. square—for the model propeller, with glass windows for observation. To vary the speed of the water apart from the speed of the model propeller, and thus control the slip, the water was circulated by a larger screw in the lower limb driven by a 50 H.P. motor. The model propeller was driven by a 15 H.P. motor through a pulley dynamometer for measuring the torque, whilst a bell-crank lever measured the thrust. The speed of the water past the propeller was deduced from the rate of circulation, which was measured by the pressure drop across a Venturi cone in the lower limb. Thus, in all essential features, the tank built by Sir Charles Parsons in 1910 resembled the tank described by the author. The investigations made with this tank had been chiefly directed to ascertaining the true nature of cavitation, and the formation and collapse of the cavities created in the water round a cavitating propeller, in connection with the phenomenon of propeller erosion. Stroboscopic methods of examination were first employed, but, later, instantaneous photographs were made use of. Considerable measurement work had been carried out in that way on propellers of various designs and types, and the results obtained were of the same character as those shown by the author. One point of difference was that the speed was varied instead of the pressure, as in the case of the author's tests; but he thought the former was the correct way to obtain true correspondence with different ship speeds, the ratio of pressure in the model experiment to that of the full-scale ship propeller being the same as the ratio of dimensions. In Sir Charles Parsons' case the pressure was taken at the centre of the propeller, and not at the tip of the upper blade, as in the author's case. Under these conditions the same relative pressures obtained at all parts of the propeller. Mr. Cook showed lantern slides of the apparatus and curves of the results obtained, remarking that the point at which the curves first departed from the atmospheric line might be described as the beginning of cavitation, although it did not coincide with the beginning of cavitation under visual observation. The cavitation round the leading edge which occurred at reduced slip values, was not identified in any way with the breakdown of the thrust curve. He doubted whether the limiting thrust followed quite so simple a law as indicated by the author. To illustrate his point Mr. Cook showed a curve of some of his results obtained at Wallsend re-plotted in terms of the actual thrust and torque to a base of slip instead of the dimensionless coefficients in the original diagram. From that curve it was seen that the breakdown in that case began at practically the same pressure at all speeds. In other experiments he had found the critical point to correspond neither with constant thrust nor constant tip speed. The truth probably was somewhere between those two extremes, but from 27 to 30 knots was too small a range of speed variation to test that relation.

Mr. M. P. Payne asked the author if the shrouding of the model propeller in a rigid tube or boundary had any appreciable effect on the results?

Mr. M. E. Denny said that a point to be considered was that water, and especially sea water, contained a large quantity of air which was liberated long before cavitation started. He did not suggest that the liberation of that air from the water had a deleterious effect comparable to what might happen when cavitation was experienced; indeed, it was obviously not so, but it was interesting to speculate whether the air released from water when the propeller started to operate did, in fact, reduce the efficiency from what would be the ideal if the water was completely air-free.

Mr. H. G. Williams referred to similar experiments to those mentioned in the paper which had been carried out by Admiral Taylor, and which were reported in the "Transactions" of the American Society last year. Those experiments were carried out in a tube about 300 mm. diameter with a propeller of about 200 mm. diameter, and the results were to the effect that practically no loss of thrust occurred until the pressure was reduced to about 3600 kilos. per square metre, which practically agreed with the author's results. Admiral Taylor, however, made the remark that cavitation would occur more quickly in an apparatus of that size working with models than it would with a full-size screw in open water. It would be interesting to know whether the author's tube was large enough to avoid such a serious error as that referred to by Admiral Taylor.

Monsieur A. Normand said that his father, forty years ago, discovered what was now called cavitation, although he called it breaking water. In 1899 and also in 1902 his father gave a considerable amount of information on the subject to the Association Technique Maritime and to the Academy of Science.

Mr. G. S. Selman said the author's method of predicting from model experiments the behaviour of a ship's propeller when cavitating appeared to provide a sound theoretical basis for the experiments of Ackeret, who showed that propeller sections cavitated at definite p/q values and that cavitation occurred when a definite vapour pressure was reached. He did not think, however, that dynamical similarity had been observed merely by relating pressures due to speed of advance based on an average wake value. Cavitation was extremely sensitive to changes of angle and induced velocities, and in the ship those were very different from those of the open model screw. The in-flow velocity varied differently over the disc, the acceleration was not approximately 50 per cent. of the whole at the propeller, as was the case in open water, and when the propellers were very close to the bracket, the angle of flow into the propeller might rapidly change as much as 40 per cent. when passing the web. For those reasons the use of speed of advance was not a good criterion. One should be careful when associating cavitation with erosion; there could be erosion without cavitation.

The author made a few comments by way of reply, but promised a full reply in writing.

The final paper taken in the morning was "Notes on Two Recent Trial Records," by W. R. G. Whiting, in which the records of the speed trials of the "Viceroy of India" and the "Polyphemus" are examined. There was a short discussion.

The meeting then adjourned until the evening, when two papers were presented and discussed. The first was by Mr. Lloyd Woolard on "The Ventilation of Warships," and the second by Professor H. S. Pengelly on "Some Steering Trials of H.M. Ships Nelson and Rodney."

Motor Shipping.

On Friday morning, March 18th, the first paper presented was "Notes on the Progress of Motor Shipping to Date," by Mr. A. C. Hardy, of which we give an abstract on page 401.

In the discussion there was a good deal of repetition of what had been said in connection with Mr. Johnson's paper. We omit it as far as possible.

Sir John Biles, dealing with a table in the paper, in which steam and motor tramps were compared, said it indicated that the expenses on a high-efficiency steamship for sea work were £3123, and the expense of a Diesel ship £3371, so that for propulsion alone the Diesel ship was the more expensive—and no account had been rendered in respect of lubricating oil for the Diesel engine. The consumption of bunkers by the steamship was given as 2½ tons per day when in port, and by the Diesel ¼ ton; but he did not know whether that difference was necessarily maintained or would be maintained. He would also like figures as to how the on-cost charges of £28 per day for the steamship and £30 per day for the Diesel ship, as given in the table, were made up. When he had put forward figures of that kind he had shown that the difference was greater. But, even supposing the table was correct, was there enough profit when using the Diesel ship to make up for the lack of ability to use coal where coal was more economical than oil? Referring to some performance figures given in the paper concerning two typical British motor ships, he asked what was meant by the author's statement that their efficiencies were 100·7 and

* No. III. appeared April 1st.

107·35 per cent. respectively. He did not know whether or not these ultra efficiencies were peculiar to the Diesel engine. However, he believed it was admitted by all that, for small powers, the Diesel engine was in many cases very much more suitable than the steam engine, especially the turbine, and it had been adopted a great deal in that field with success. Commenting on the final sentence of the paper, in which it was stated that although tonnage production figures for the world were exceedingly low, those for motor shipping appeared to be holding their proportionate position quite well, Sir John pointed out that there had been a reduction in motor ship construction from 637,000 tons in the quarter ended September, 1930, to 162,000 tons in the quarter ended September, 1931, *i.e.*, there had been a reduction to the extent of about three-quarters. On the other hand, the reduction of steamship tonnage was only about a half. If Mr. Hardy was satisfied that motor ships were holding their own in face of such figures, he was a happy man.

Mr. A. L. Ayre pointed out that the tramp steamer referred to in the author's table comparing steam and motor tramps was a high capital cost ship which he believed had an exhaust turbine, superheaters, and perhaps, one or two more of the things which had been referred to as gadgets. In recent times, however, owners were asking for all the economy that was possible, but were demanding that their ships should be free from gadgets and any intricate things which seemed to break down; they wanted something foolproof and simple, and one owner had expressed the desire that his ship should be free even from superheaters. He urged, therefore, that simple low-capital-cost steamships should be compared with Diesel ships. He agreed with Mr. Hardy that the initial cost of ships was of the utmost importance. Discussing the question as to whether or not speed paid, he said that in recent years his firm had worked out that problem with various owners, and had found time after time that, certainly on freights as existing to-day, speed did not pay. A tramp carried a class of cargo for which the shipowners could not obtain high freight rates. So long as the shipowners found that, with the low-capital-cost ship in particular, it was wise to run at only 9 knots, he did not see that the Diesel could look at the steam tramp. In a trip from the United Kingdom to the Plate and home again at that particular speed the steam tramp would earn double the earnings of the Diesel ship as a dividend return on the capital invested.

Mr. S. S. Cook said that the author had set up a fuel coefficient of 64,000 as his standard of perfection, and in figures representing the voyage performance of a typical motor liner, he had advanced that high value of the oil coefficient for the purpose of contrasting the performance of that ship with the performance of similar liners propelled by steam power. The 58 tons given for the latter might be shown to be grossly understated. Taking the oil per B.H.P. at 0·39, the consumption would be 75·2 tons per day at 18,000 S.H.P. Reducing the power, however, to 16,200 B.H.P., to agree with the author's figure for the actual revolutions per minute, viz., 130·5, the same consumption rate gave a fuel consumption per day of 68·4 tons. That figure, however, related to propulsion only; to arrive at the fuel consumption for all purposes one could not add less than 0·05 lb. per B.H.P. for a liner, with its large hotel services, making 0·44 lb. per B.H.P., and 76·5 tons per day at 16,200 B.H.P. The fuel coefficient then worked out at about 67,000 instead of 88,120, and the figures given in the paper should be amended. The fuel coefficient for the "Empress of Japan" was 55,000 over several voyages, for all purposes, so that taking 67,000 as the true figure for the author's ship, it would be seen that, when fuel prices were taken into account, the comparison was in favour of the steam-propelled vessel—and still more so when allowance was made for difference in first cost.

The author's comparison of steam and motor tramps was regarded by Mr. Cook as of little value. He pointed out that nothing was said about the difference in weight of machinery, and the fact that difference in deadweight did not always represent increased weight of revenue-earning cargo was conveniently overlooked.

Mr. Jaques du Bois (M.A.N.) referred to the achievements of Germany in the development of the Diesel engine, and extolled the merits of the two-stroke double-acting type of engine, adding that for the largest powers that type of engine offered the best and, in some cases, the only possible solution. Commenting on a statement in the paper that Germany had 161 motor ships in service with a total gross tonnage of 547,116, he said that seventeen of the ships, with a total gross tonnage of 156,000, were driven by double-acting, two-stroke engines. Therefore, it could safely be said that the percentage of that type of engine was well above 10 per cent. in relation to the number of ships, and 27 per cent. in relation to the tonnage—a remarkable figure in view of the fact that that type had been on the market only since 1925. The two largest Spanish motor vessels, and 75 per cent. of the motor ships commissioned in Japan during the last few years, were propelled by the two-stroke, double-acting type of engine.

Engineer-Commander C. J. Hawkes felt that each type of machinery had its uses, but as a sea-going engineer, having to deal with large powers, he would prefer the steamship. On the other hand, there were cases in which the motor ship was justified. With regard to repair bills, the difficulties which had been met with in respect of many engines—apart from inherent defects in design—were due very largely to the fact that the staffs were not suitable for that particular machinery. Ordinary reciprocating steam engines wanted looking after and overhauling occasionally, and if that were not done repair bills would arise; but the Diesel was far more sensitive than the steam reciprocating engine.

Mr. Robert Sulzer, whilst agreeing that there were many cases in which the two-cycle double-acting engine had advantages over the single-acting engine, said that in the case of the new Belgian cross-Channel ship there had been very strong arguments for it, but after very careful consideration single-acting engines were adopted. It could not be said as a matter of principle that a double-acting engine was the most suitable for certain powers; the merits of each case must be considered. In connection with the Belgian ship it was considered that the engines should be of fairly high revolutions and that there should be a direct-driven propeller. The gear-driven arrangement ought to be avoided as far as possible, for there was no more effective and simple way of driving a ship than by transmitting power by the shortest route from the combustion chamber to the propeller, as was done with the direct drive. The engine revolutions in the Belgian ship were to be 250 and the S.H.P. 6500, and the comparisons made had shown that the single-acting engine was probably more advantageous than the double-acting. The double-acting engine required a higher engine-room for dismantling—at least, if the pistons were to be taken out from the top, which was quicker than dismantling from below—and the ratio of stroke to number of revolutions was more favourable in the single-acting engine. In fact, with the single-acting engine it was possible to go to a much higher piston speed and therefore to get a quicker stroke on account of the shorter piston, and the double-acting engine would have less mechanical efficiency than the single-acting. The difference in weight as between the double-acting and single-acting engine was only about 3 per cent. Finally, he said that every type of engine had proved its suitability to particular needs and circumstances. He had been interested to note how strongly British engineers still adhered to the steamship, and he could quite understand their way of looking at the matter, having regard to the fuel available to them. That fact also supported the argument that one should not generalise.

Mr. Hardy, replying to the discussion, intimated that he would answer the detailed criticisms by means of a written communication.

The next paper to be taken was that presented by Mr. E. Wilding, an abstract of which is printed below.

MECHANICAL EFFICIENCY AND MARINE OIL ENGINES.

In this paper the author discusses the presentation of B.H.P. and I.H.P. data on marine oil engine trials, and applies the Friction Remainder Analysis of the late Mr. R. E. Froude in order to facilitate a more accurate presentation of the mechanical efficiency, basing his calculations on recent shop trials.

It will be remembered that in this Mr. Froude had derived what was in effect the B.H.P. from the performance of the propellers, not having actual B.H.P. figures for the steam machinery.

Now both the B.H.P. and the I.H.P. contain, as a common factor, the revolutions per minute, and taking out this common figure he arrived at what he called the "Friction Remainder" by deducting from $\frac{\text{I.H.P.}}{\text{Revs.}}$ the term corresponding to $\frac{\text{B.H.P.}}{\text{Revs.}}$ and this was plotted on a base of $\frac{\text{B.H.P.}}{\text{Revs.}}$

This Friction Remainder for steam engines had a "straight-line" characteristic, and such Friction Remainder includes any errors in the I.H.P. and B.H.P. determinations which do not balance out in addition to losses in the engine itself and the line of shafting.

It was then considered that in an open type of reciprocating steam engine the Friction Remainder should, in fact, consist of two parts, one a constant part corresponding to dead load friction and the other part proportional to the torque being transmitted by the engine, and the diagram was based on this theory. It was found that a sloping straight line represented the mean results. The Friction Remainder being in effect the complement of the mechanical efficiency.

There is no difficulty with an oil engine in following up this form of analysis because it is proportional to the difference between the indicated mean effective pressure and what the Marine Oil Engines Trials Committee termed the "brake mean effective pressure."

The values of the Friction Remainders thus defined were made out from the brake tests of the engines in the shop and plotted on a base of the $\frac{\text{B.H.P.}}{\text{Revs.}}$ to see if a straight line could be found which could be reasonably taken as being the mean of the spots obtained at the different speeds with a view to eliminating—or at any rate minimising—the accidental errors which are inevitable in getting the I.H.P.s from the indicator diagrams.

Such Friction Remainders for an oil engine clearly include the torques required to operate air compressors, and scavenging and other pumps—if not independent—just as they would, for example, include the torque to operate an air pump for a steam engine if not independent. But from the point of view of considering the propeller performance this was not material, as what mattered was the overall mechanical efficiency.

The diagram obtained from the plotted brake tests of relatively high-speed port and starboard engines was an approximately horizontal straight line. This result, although surprising, was confirmed when the indicator cards were checked, and it was further tested by applying it to the trial results under way. The author recommends the method as one offering greater facility in the examination of the trial results of oil-engined vessels, and illustrates it by diagrams worked out from the shop trials of the Marine Oil Engines Trials Committee, which are fully discussed.

Engineer-Commander C. J. Hawkes, opening the discussion, said that for many years he had been a critic of I.H.P. figures, because he knew the difficulty of getting the exact power and in checking it. Although a member of the Marine Oil Engine Trials Committee, he did not necessarily accept as accurate all the I.H.P. figures given by it; indeed, in most cases they were far from the mark. Owing to the method of setting the indicator rig, it was very often at fault. In one case he could not accept the figures given for mechanical efficiency, especially when the engine was developing roughly 25 per cent. of its output. He had checked the whole of the indicator rigs from the cylinders and had found that the discrepancy was of the order of 7 lb. per square inch, which, when the engine was running at 25 per cent. of its load, came to a very big figure—it was something of the order of 25 per cent. error. He was not surprised, therefore, that at the lower powers the author had secured results which were all over the place. The paper was extremely interesting because it had brought out a point of difference between the oil and the steam engine. In the steam engine the pressure changed as the load fell, but in the oil engine the pressure on the bearings was practically the same, whether the engine was working at quarter load or full load. Taking that fact into account, and neglecting any other changes, one should obtain a straight line. In the supercharged engine there was a tendency, he believed, for pumping loss to change with power; that might have some effect on the efficiency which could not be determined. Dealing further with the I.H.P., he referred to trials he had carried out on a single-cylinder engine in which only one change had been made, and that change concerned the instant of fuel injection; the change did not affect the fuel consumption or the B.H.P., but it had affected the mechanical efficiency appreciably—to the extent of about 6 per cent. That fact again indicated how extremely difficult it was to obtain data from I.H.P.; certainly it was difficult to compare one engine with another. It seemed to him that one was likely to get far nearer the B.H.P. on the total fuel consumed than on any other basis.

Mr. C. W. J. Taffs, in a written communication, said the author had determined a set of friction remainders for an engine by subtracting the B.H.P. from the corresponding I.H.P. and dividing by the common revolutions per minute. Such friction remainder divided by 2π was the torque required to overcome the frictional resistance of the engine, including the torque required to turn the auxiliaries, such as the injection air compressor. This friction remainder in the form of torque could readily be converted into an equivalent pressure on the pistons, and he submitted that, as a basis of comparison, the author might with advantage have expressed his friction remainders in that way. In plotting the ratio mean indicated pressure/mixture strength to a base of mixture strength, using the mean indicated pressures recorded in the Marine Oil Engine Trials Committee's reports, it would be found that whereas some of the engines showed a maximum for the curves, others showed a minimum, which phenomena could not be interpreted physically. Accordingly, a mode of correction of the mean indicated pressures was sought. Instead of ascertaining a friction remainder, which included a torque to turn the auxiliaries, as the author had done, he had ascertained the purely mechanical friction of the engines and had expressed it as a pressure referred to the pistons. In the case of the two-stroke cycle engines the figure was 8 lb. per square inch, and in the case of the four-stroke cycle engines it was 16 lb. per square inch. Using those values of the pressure equivalent of the mechanical friction, figures corresponding to the I.H.P. and the mean indicated pressure were computed. The corrected mechanical efficiency curves for each of the six engines were exhibited. They were in all cases much better conditioned curves than those recorded in the reports. Moreover, when the indicated pressures, corrected in the way described, were divided by the appropriate mixture strengths, the curves which previously had shown minima had conformed to what only was possible and had shown maxima.

Mr. J. F. Petree thought the author was inclined to exaggerate the effect of the viscosity of the oil upon the friction in the lightly loaded condition as compared with the fully loaded condition. So far as he could trace, the difference in temperature of the lubricating oil as between the full-load and light-load condition was comparatively slight.

Mr. G. S. Baker (National Physical Laboratory), in a written communication, said that the difficulties met with, over a number of years, in getting an accurate measure of I.H.P. on oil engines, had led him to give up hope and to concentrate on the direct measurement of S.H.P. During that time he and his colleagues had not tried to use Froude's friction remainder analysis, and they were indebted to Mr. Wilding for having drawn attention to the applicability of that old method to the more difficult class of main engine, when one was compelled to accept I.H.P. as a power measurement.

There was another method of picking out the probably correct data, due, he believed, to R. E. Froude, *i.e.*, to work out the effect of small errors in any measurement upon other allied data. A screw

was a mathematical instrument, and in its absorption of power and delivery of thrust obeyed certain broad laws. He was not sure whether Froude had published that method, but in an old "Haslar" note book there were several equations giving the variation of torque, revolutions, &c., necessary to balance given small variations in power.

Mr. R. J. Butler, in a written communication, said that it was difficult to visualise that an increase in the mean effective pressure in the cylinders could actually reduce the frictional torque from that which must necessarily be expended to overcome motion at zero or low revolutions, and the downward slope to the right of the line of frictional remainder indicated that state of affairs. The suggestion that the lubricating oil might be less viscous when the engine was on full load was not very likely to be the right explanation of the results obtained, as the difference was usually only a matter of a degree or two after the oil had passed through the oil cooler.

Mr. Wilding's method, however, did offer a ready means of analysis of trial results of oil-engined vessels and facilitated the elimination of indicated powers which were open to suspicion. His method had been applied to the results obtained from very fast-running engines, and had in all cases shown that a straight line sloping upwards to the right very fairly represented the recorded figures.

Mr. Wilding, replying to the discussion, said he agreed thoroughly with Engineer-Commander Hawkes as to the lack of reliability of the I.H.P. figures; but, in the ordinary course of commercial trials on oil engines run in the ordinary way, nothing except I.H.P. figures could readily be obtained. His experience of attempting to use an integrating torsion meter to determine the variable torsion of a Diesel oil engine, and in the cramped space available afloat, had not been encouraging. The B.H.P. tests in the shop were probably the best power tests obtained on any oil engine. The adoption of Mr. Baker's interesting suggestion, that the problem might be attacked from the screw end of the problem, led to very heavy mathematical work which one could not undertake in a hurry on a trial. The whole object of the paper was to try to provide a somewhat more ready means of making a prompt analysis of the data ordinarily obtained in the trials, and he had not heard any adverse criticisms from that point of view.

A paper entitled "Fuel Consumption of Steam-driven Auxiliaries in Diesel-engined Tankers" was then presented by W. H. Dilworth. There was no discussion upon it.

The last paper of the session bears the title "Experimental Investigation upon the Effect of Temperature on the Skin Friction Resistance of a Flat Plate Immersed in a Turbulent Stream." It was written by Mr. J. H. Lamble, and gave rise to a short technical discussion. After its presentation the meetings closed with the usual votes of thanks.

SIXTY YEARS AGO.

In almost every respect the life of the artisan and industrial worker was much harder sixty years ago than it is to-day. In one instance, however, recorded in our issue of April 12th, 1872, comfort was studied to an extent which led to an accident. In general the railway companies were deaf to the appeals made to them to provide shelter for their engine drivers, gatemen, and pointsmen, but with a strange inconsistency they showed much concern for the protection of their signalmen. At least it was so on the North Staffordshire Railway at Stoke-on-Trent. The holes in the floor in which the point and signal levers worked admitted draughts. In the cabins north and south of the station the signalmen were provided with large comfortable high-backed armchairs having cushioned seats and glass windows at the sides. In the south cabin the chair was placed in front of the fire, with its back towards the signal and point apparatus. These facts were brought to light by Colonel Rich, the Board of Trade Inspector, when he visited the cabins after the inevitable accident had occurred. He protested strongly against this pandering to the comfort of the signalmen. They were on duty, he remarked, for twelve hours at a stretch and the chairs definitely encouraged them to go to sleep when they should have been alert and attending to their work. The chairs, he recommended, should be removed at once. If the men were too delicate to perform their duty without them they should be invalided out of the company's service and others, more robust, engaged in their places. Only parenthetically did he mention the possible desirability of shortening the hours of work. . . . Another little picture of how things were done in those days is contained in the same issue. At Moscow an exhibition was to open in about two months' time. The exhibitors in the machinery section were, however, very uneasy and dissatisfied with their prospects of being able to show their wares. For one thing, the machinery, according to the arrangements made by the exhibition authorities, was to be driven by wire ropes from a 20 horse-power engine installed a quarter of a mile away from the machinery building. For another the spaces allotted to the exhibitors were greatly in excess of the room available, and it was quite possible that many of the stands might have to be erected in the open air. In several directions, however, the contractors for the exhibition buildings had made good progress. They had finished the restaurant building, the soda water bar, and the newspaper, police, and telegraph kiosks. These buildings were ready, but such was the nature of the work which had been put into them, that doubts were seriously entertained whether they would not collapse before the exhibition opened.

American Sea-Going Train-Ferry Steamers.

By E. E. R. TRATMAN.

No. I.

The Great Lakes of North America, five in connected series, have been termed the "unsalted seas" in view of their great extent, their navigation and their occasional storms which render them dangerous as well as useful. An interesting and important feature of the American railway system and of the navigation on the Great Lakes is the car-ferry, or train-ferry, service across Lake Michigan, where five railways operate nine different routes, while a sixth railway is proposing to put boats on two additional routes. Thus, Lake Michigan has by far the most extensive train-ferry system in the world, with nearly twenty boats in continuous operation, day and night, winter and summer alike.

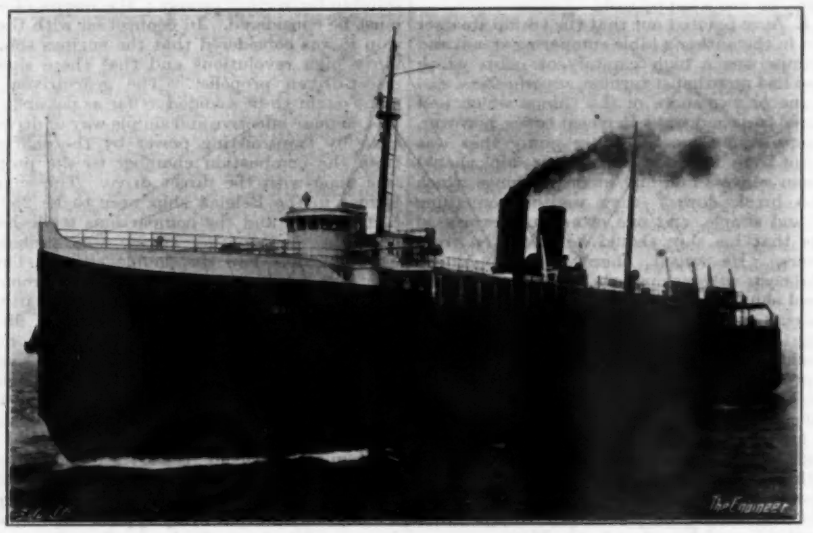


Fig. 1—Train Ferry Steamer "Wabash"

This lake is approximately 60 to 80 miles wide and 360 miles long, and these long-distance deep-water or "sea-going" train-ferry steamers are of a very different character from those of the numerous routes across the large American rivers. Except for one short—10 mile—route across the Straits of MacKinac, at the head of the lake, the trips are 65 to 110 miles in length, and the voyages take five to seven hours. Passenger trains are carried only on the short route just mentioned, but nearly all the steamers carry a limited number of motor vehicles on the train deck. Two typical twin-screw train-ferry steamers are illustrated herewith—the "Wabash," Fig. 1, with triple-expansion engines, and the "City of Flint," Fig. 2, with turbo-electric machinery. These boats will be described later, together with those of several other lake lines and some salt-water lines also.

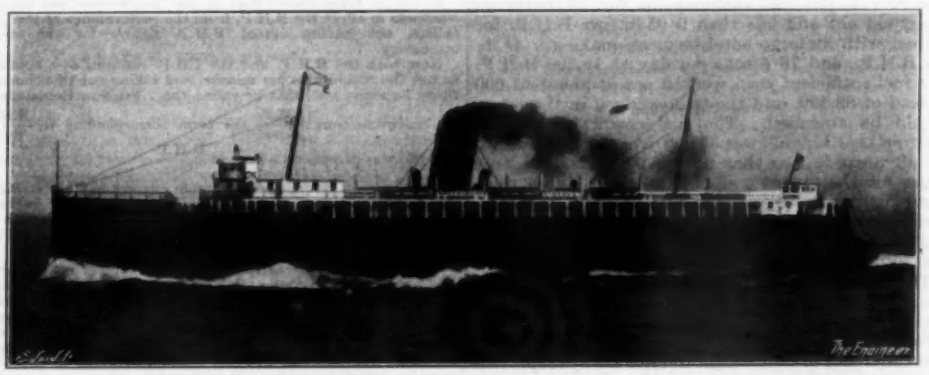


Fig. 2—Turbo-Electric Train Ferry Steamer "City of Flint"

These Lake Michigan train-ferries are in operation daily throughout the year, and have to encounter severe conditions owing to violent storms and heavy ice. It is only rarely, however, that a trip is cancelled on account of rough weather, although, in winter, the boats are likely to be delayed occasionally by having to force their way through the ice fields or the masses of ice piled up near the shore by high winds. As a rule the boats do not run according to regular schedules or time-tables, but they make as many trips as are necessary to handle the business promptly. At periods of heavy traffic, therefore, an incoming boat may discharge its load of cars, take on another load and start at once on another trip. However, for the accommodation of motor vehicles and passengers, some of the lines run a few boats daily at stated times, and such additional boats as may be required.

To account for this extensive train-ferry service it may be explained that Lake Michigan intercepts, or intersects, several direct railway routes. Railway goods traffic between eastern and central points and the great North-west area, with its large cities and rapid industrial development, has the choice of a rather indirect all-rail route passing around the south end of the lake, or a shorter and more direct rail-and-water route, in which the cars are ferried across the lake, without any unloading and reloading of freight. In addition to the factor of distance, there are inevitable delays in moving freight through the congested lines at the termini or the goods yards of great cities and industrial centres. Delays are more especially experienced when cars brought in on one railway have to be transferred to other lines to continue their journeys.

As an example, the distance between Detroit, below Lake Huron, and Duluth, at the head of Lake Superior, is approximately 700 miles by different all-rail routes, with transfer at Chicago. But this transfer involves delays which are due to breaking up trains in the yards of one road, transferring them to the yards of other roads and then getting them arranged in outbound trains for their final destinations. By different rail and train-ferry routes, however, the distance is from 600 to 640 miles, the incredibly congested district around Chicago is avoided, and there may be a saving of ten to twenty hours on the trip. Besides that, the liability of damage to goods by shunting in two or three goods yards is avoided.

Severe storms and high seas are not infrequent, but the ice conditions are more troublesome owing to their long continuance. The ice is sometimes 3ft. to 6ft. thick, and may be piled up as high as 14ft. by the wind. In deep water, the boats manage to break through, either by means of their inclined stems and wedge-shaped bows, designed as ice-breakers, or by backing into the ice, so that the screws create a swirling movement of the water and a downward current or suction that disturbs and dislodges the ice. The train-ferry "Chief Wawatam," in the ice in the Straits of Mackinac, is shown in Fig. 3. This boat also will be described later.

At some of the ports trouble has been caused by ice packing in the channel between parallel jetties, which protect the harbour entrance. Such a solid mass is difficult to break or dislodge. These jetties were built many years ago, long before the advent

of train-ferry steamers, and other large craft. At some ports they have, in recent years, been replaced by converging breakwaters extending from the shore, the entrance between their heads giving access to a large sheltered bay instead of a long and comparatively narrow channel.

Development of Train-ferries.—This train-ferry system was initiated in 1888, when the Mackinac Transportation Company put in service a boat across the Straits of Mackinac, at the head of Lake Michigan, to connect the Michigan Central Railroad terminus at Mackinaw City with that of the Duluth, South Shore and Atlantic Railway at St. Ignace, a distance of about 8 to 10 miles.

For the larger or open-sea crossing of the lake itself, the Ann Arbor Railway was first, putting two boats in operation in 1892 between its terminus at Frankfort, and that of the Green Bay and Western Railway at Kewaunee. Later, it established additional routes from Frankfort to Menominee, Manistique and Manitowoc. In 1897, the Pere Marquette Railroad entered the field. This line ends at Ludington, some 80 miles south of Frankfort, and its first service was with one boat between Ludington and Manitowoc. A third railway started a boat between Muskegon and Milwaukee in 1898,

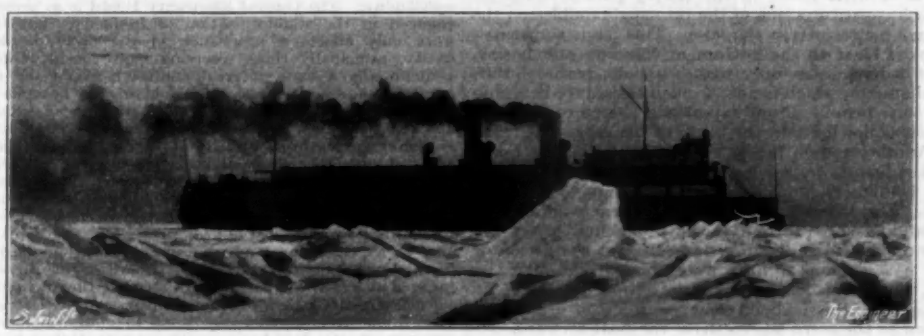


FIG. 3—TRAIN-FERRY STEAMER "CHIEF WAWATAM" IN THE ICE

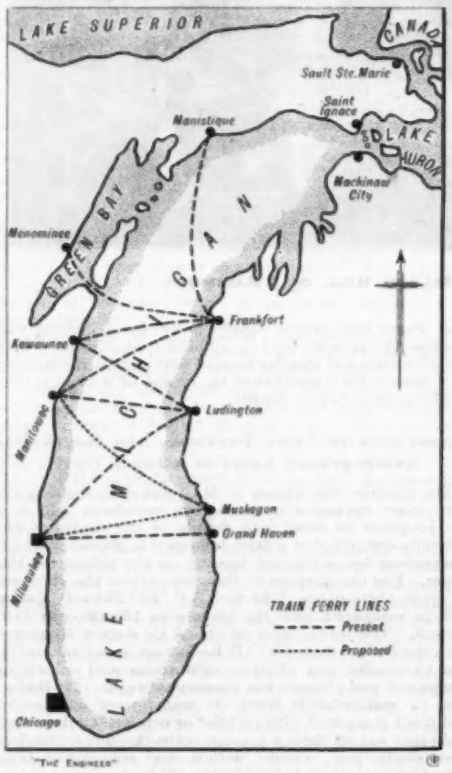


FIG. 4—TRAIN-FERRY ROUTES ACROSS LAKE MICHIGAN

but this railway was soon acquired by the Pere Marquette, which then changed the route, operating the boat between Ludington and Milwaukee. To these two routes it later added a third, to Kewaunee. In 1906 the Grand Trunk Railway started its train-ferry between Grand Haven and Milwaukee. These several routes are indicated on the map, Fig. 4.

Most of the ten train-ferry ports are served directly by two to four railways although Frankfort and Ludington have but one railway each. As all these railways have numerous connections with other lines, their train-ferries serve as links in various through routings, the cars coming from and being destined to innumerable cities and towns, far and near. Each railway has from two to eight steamers, or about twenty in all, and in one recent year the traffic on all routes aggregated 4,400,000 tons of freight and 14,000 passengers.

For several years the Grand Trunk Railway—a part of the Canadian National Railway system—has operated a line of boats between Grand Haven and Milwaukee, but it has decided to operate also between Muskegon and Milwaukee. The Ann Arbor Railroad operates four lines from its terminus at Frankfort to Manitowoc, Menominee, Kewaunee and Manistique. The Pere Marquette Railroad operates three lines from its own terminus at Ludington to Milwaukee, Manitowoc and Kewaunee, and now the Pennsylvania Railroad is planning to extend its great system across the Lake by train-ferry lines from Muskegon to Milwaukee and to Manitowoc.

The distances range from 65 to 100 miles, the largest being from Ludington to Milwaukee and northward from Frankfort to Manistique. The time is from 4½ to 7 hours, according to distance, weather and load, and the engine power. Most of the boats have a sea speed of 14 miles an hour, but the new turbo-electric steamers, put on in 1930, can make 18 miles an hour. For the short route across the Straits at the head of the Lake the time is forty-five to sixty minutes. The several routes and approximate distances are as follows :—

	Miles.
Grand Haven to Milwaukee	85
Ludington to Milwaukee	100
Ludington to Manitowoc	65
Ludington to Kewaunee	65
Frankfort to Manitowoc	80
Frankfort to Menominee	80
Frankfort to Kewaunee	65
Frankfort to Manistique	100
Mackinaw to St. Ignace	8

Train-ferry Steamers.—Owing to the heavy storms, rough seas, the dangers of a lee shore, the severe ice conditions, and the necessity of maintaining services all the year round, the train-ferry steamers have to be thoroughly staunch and seaworthy and powerfully engined. A high freeboard and a covered or enclosed train deck are thus essential, as an open deck at that level would be buried under the heavy seas. In this respect the conditions of the lake boats differ widely from those of the numerous train-ferry steamers which operate on river routes and have only light superstructures above the train deck.

In appearance the lake train-ferry steamers resemble lake and ocean cargo boats, except for the stern opening—or bow opening in a few cases, as noted later—to admit the trains. This arrangement above the main or train deck gives a peculiar or distinctive appearance. During the voyage the opening is partly closed by a hinged bulwark about 6ft. high. Structurally, the hull up to the main deck is of very heavy construction, with bulkheads forming water-tight compartments and with heavy framing and diaphragms to reinforce the ice breaker bow. Above this main deck the frames and side plating are continued to the upper deck, which forms the roof over the train deck

On account of the exceptionally severe ice conditions and the necessity of keeping navigation open in spite of these conditions, the train-ferry steamers are all designed as ice breakers. The special form of bow for this purpose—illustrated in Fig. 5—is one of the distinctive features, and is based on long experience. It will be seen that, beginning at about 5ft. above the

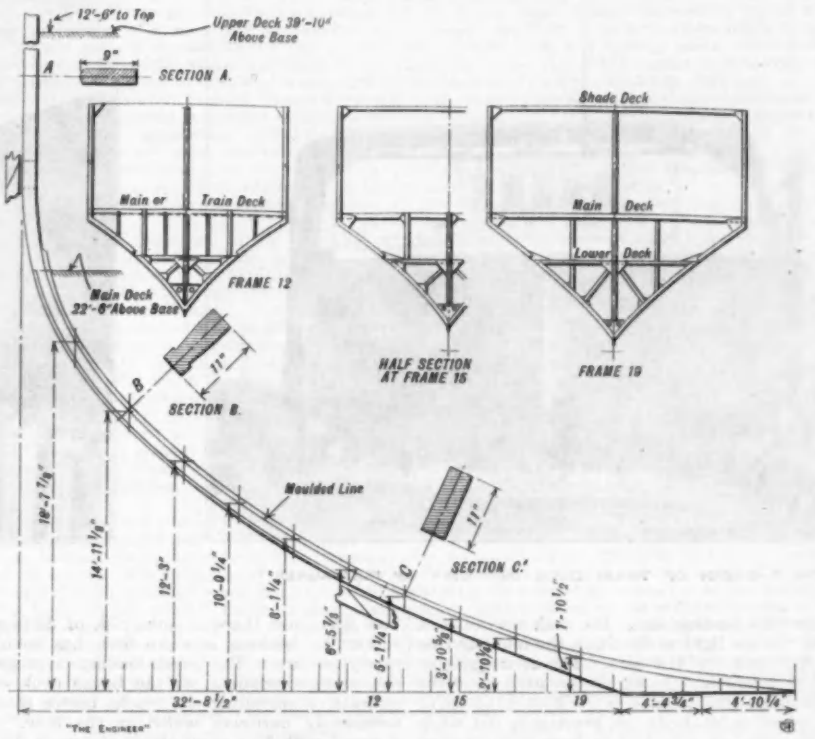


FIG. 5—ICE-BREAKING BOW OF S.S. "WABASH"

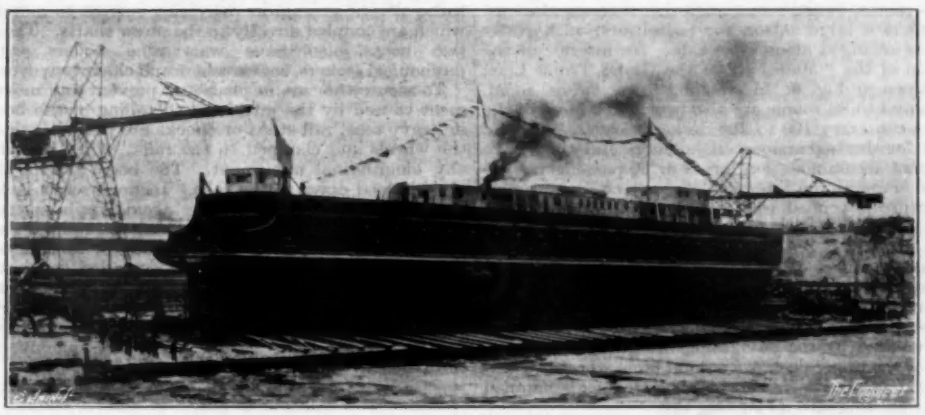


FIG. 6—TRAIN-FERRY STEAMER "MADISON" ON THE WAYS

train deck level, the stem slopes back in a long curve that meets the keel about 40ft. from the bow perpendicular. Furthermore, in this 40ft. distance the sides of the hull slope inward sharply from the deck level to the stem, thus forming a decided wedge section, which is heavily reinforced.

If the ice is too thick or massive to be sheared and thrust aside by the sharp stem, the forward movement of the boat will tend to cause the fore part to ride up on the ice and thus break it and crush it down by the wedge-shaped bow, and the great weight of the steamer. Aft of this special bow construction, the hull is of the usual approximately rectangular section, with flat floor and heavy keel plate and girder.

The peculiar form of open stern construction above the train deck has been mentioned, and is well illustrated in Fig. 6, which is a view of the "Madison," of the Grand Trunk Railway. This view is of interest also in showing how these boats are built on short ways for launching sideways. The stern opening of the "City of Milwaukee," of the same line and built in 1930, is shown in Fig. 7, the vessel being moored against the landing apron or bridge. The men are standing in line with the end of the deck. On the apron are the two land or approach tracks, diverging to the four lines of rails on the deck. This view shows the closely spaced side frames and the row of pillars or columns on the centre line, supporting the upper or spar deck.

At the after end of this upper deck is the auxiliary wheel-house, from which the ship is handled when backing into its landing slip. On each side of it is a powerful electric light to facilitate the manœuvring and the movement of the cars. The stern gate or bulkhead is raised and looks like an arch over the deck. The horizontal portion is the bottom boom, as the gate, which is 5ft. high, lies practically flat when raised. Its ends are attached to long arms pivoted above the side bulwarks, its heavy weight being balanced by counterweights on chains leading from the ends of the gate and over guide sheaves on tall standards at the corners of the upper deck. One of these chains and standards is shown at the left of the engraving.

Long superstructures on the upper deck contain the officers' quarters, deck crews' quarters, galley, mess rooms, dining room, and other accommodations. There is a large saloon for passengers, with state-rooms arranged along each side. An interior of the saloon of the "Madison," of the Grand Trunk Line, is shown in Fig. 8. A smoking-room, ladies' room, bath and toilet rooms are also provided. Most of the boats can carry 100 to 200 deck passengers, as when used for day excursions on holidays and they have sleeping accommodation for 40 or 50 passengers.

On some of the later and larger boats, the superstructure is topped with a promenade deck or boat deck extending the full width of the hull—as in Figs. 1 and 2. Above the forward break of the promenade deck is the large wheel-house or pilot-house, and in some cases the officers' quarters are in a structure adjacent to the pilot-house. In other cases, the pilot-house is above this structure, and is surmounted by the navigating bridge. At the after end of the upper deck is a second large wheel-house—mentioned above—from which the steamer is handled when backing into its landing slip.

Engine-rooms, boiler-rooms, coal bunkers, &c., are all below the train deck. Along the centre line of the deck is a narrow enclosure containing the stairways to the upper deck, the companionways to engine and boiler-rooms, and the ventilator shafts and uptakes to the funnels. On the train deck are four lines of rails, each accommodating six to eight goods wagons having an average length of 42ft. over the couplers. These tracks converge into two at the stern. Their forward ends terminate at massive steel bumpers or buffer stops built into the deck framing.

The twin screws are well housed under the stern.

In some of the earlier boats a third screw was arranged at the bow to assist in displacing the ice. This arrangement is of practical value mainly with massive solid ice, such as is encountered in the Straits of Mackinac, where the bow screw is still used. It is of little effect in the deeply packed slush ice which constitutes one of the principal troubles on the longer routes across the lake. This ice is sometimes packed clear to the bottom in channels and basins. But a bow screw only makes a hole, perhaps 15ft. in diameter, which is not of much assistance to a ship of 56ft. beam. From experience therefore the bow screw is not used on the boats of the cross-lake lines.

Another reason for its continued use on the boats of the Straits train ferry is that these boats are built for loading and unloading cars at the bow, instead of at the stern. Consequently, when heading into a landing slip full of ice, the propelling screws are of no effect in dislodging the ice. But the action of the bow screw is to draw water down from under the ice, which thus loses much of its support at the same time that the inclined bow or forefoot crushes it down as the stern screws drive the boat forward.

All the boats on the other routes load and unload cars at the stern, and therefore back into the landings, the screws then serving both to pull the boat in and to dislodge the ice. This requires more manœuvring in turning and backing than is required with entering bow first, and there is some risk of damage to the rudder by backing in stern first, but such damage rarely occurs. The stern-loading arrangement is the more convenient, as the broad deck or fantail permits of spreading the tracks better than on the necessarily narrower width at the bow. Further, a vessel with bow open above the main deck would hardly be seaworthy in rough weather on the open Lake, when seas breaking on the bow throw volumes of solid water on the upper deck.

For propulsion all the boats have twin screws, which are controlled independently so as to assist in turning and manœuvring. Most of them have triple-expansion engines and Scotch boilers, and all burn coal. But two boats put in service in 1930 have turbo-electric generators delivering current to motors which are coupled directly to the screw shafts. These two boats also have water-tube boilers with mechanical stokers, coal crushers and chain conveyors.

To secure the cars in place and prevent any movement caused by the pitching and rolling of the boat in heavy seas, rail stops or chocks are placed against the wheels and clamped to the rails. They prevent any longitudinal movement. The bogie trucks are also chained down to the rails. Inclined screw jacks are set with their feet resting against rails riveted to the deck plates, while their heads are shaped to fit the bottom corner of the car body or its side sill or sole-plate. These jacks are extended so as to take the weight of the car body off the springs and give the body a rigid support, so that it cannot rock or sway on the springs if the boat encounters heavy weather. And storms arise very quickly on the Lakes.

(To be continued.)

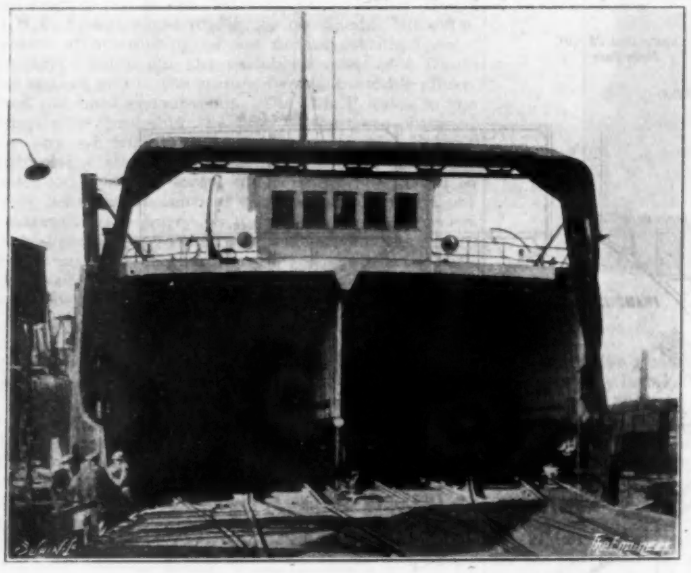


Fig. 7—Stern of Train Deck of "City of Milwaukee"

Fig. 8—Saloon Hall of "Madison"

The Montreal Light, Heat and Power Consolidated added 20,000 new gas and electric customers to its list in 1931, according to the annual report. Electric customers now number 240,965 and gas 191,879. The company's output of gas during the year amounted to 6,096,723,000 cubic feet, while the electric output was 1,557,929,949 kWh. The territory covered numbered a population of 1,293,092.

The Change-over of Low-Tension Distribution Systems from Direct Current to Alternating Current.*

The advantages to be derived by users of electricity and manufacturers of electrical apparatus from standardisation in the voltage and type of current supplied are well known. The Central Electricity Board is at present engaged in the standardisation of frequency, but this work only affects a proportion of the users of electricity, principally those receiving high-tension supply. Undoubtedly a state of great confusion exists and the question of standardisation of low-tension systems is of the utmost importance. Although where new systems are being laid down a standard three-phase, four-wire system at a pressure of 400/230 volts is being adopted, there are still numerous non-standard systems, the majority operating on direct current. Users of these non-standard types of supply and manufacturers of apparatus connected thereto will, no doubt, wish to participate in the benefits of standardisation, and in the near future a strong demand may be expected for a national standard of low-tension supply. The Central Electricity Board is at present engaged at a heavy expenditure in securing the maximum efficiency in the generation and transmission of electrical energy, but it is equally important to obtain increased efficiency in its distribution. The recent high rate of increase in the demand for electricity, and the belief that the future will bring a still more rapid growth of load, have compelled supply authorities to consider increasing the capacity of their low-tension distribution systems, and the authors have endeavoured to show that where the present supply is by direct current this increase in capacity may be obtained concurrently with the advantages of standardisation and increased efficiency at a reasonable expenditure by means of a change-over to alternating current supply.

Change-over in Small Townships and Residential and Suburban Areas of a Large City.

The relative advantages of D.C. and A.C. distribution have been discussed on numerous occasions, and it is not proposed to enter into details of the merits of the different systems, but a brief summary is necessary as the comparison has a distinct bearing on the subject of this paper. For the purpose of this comparison the standard 50-cycle, three-phase, four-wire A.C. 400/230-volt system will be compared with the three-wire 460/230-volt D.C. system. The advantages of the A.C. system compared with the D.C. system are: (1) Reduction in capital outlay, due to smaller and cheaper substations and substation equipment and cheaper low-tension networks. (2) Reduction in maintenance costs on transformer substations and plant compared with rectifier or converter substations and plant and on the low-tension networks, due to freedom from electrolysis, osmotic action, and consequent large reduction in the number of faults. (3) Reduction in valuation for rating purposes. (4) Increased efficiency, due to reduction in running losses of transformers as compared with transformers plus convertors or rectifiers, and due also to the smaller feeding radius of substations. (5) Increase in elasticity of system due to: (*a*) Increase in number of substations, (*b*) comparative ease with which increase of load or alteration of load centre may be met by inserting a transformer centre where required, and (*c*) greater ease with which a heavy low-tension A.C. consumer may be transferred to high-tension supply.

Apart from power factor, it may be said that an A.C. system has practically no disadvantage when compared with a D.C. system.

There seems no doubt, therefore, that an A.C. system of distribution is better than a D.C. system, but, where the latter is already in existence, supply engineers have to decide whether it is worth while to alter it to obtain the advantages enumerated above. Apart from the inherent advantages of the A.C. system, the demand for standardisation and the abnormal growth of load within the

* Abstract of paper read by Messrs. H. Blades and A. C. MacQueen. before the Institution of Electrical Engineers on March 31st.

last few years have compelled consideration of the question of change-over. The demand for a standard system of low-tension supply is yearly becoming more insistent. The recent rapid growth in the demand for electricity has resulted in many existing D.C. systems becoming overloaded, and to make proper provision for the future it would in some cases be necessary to double or even quadruple their carrying capacity at a heavy expenditure in D.C. plant and cables. If, without an undue increase in this expenditure, the necessary areas could be changed to alternating current and at the same time the increased capacity obtained, there would be no doubt as to the advantage of doing so.

It is less expensive to install an A.C. centre and change over the network to be supplied from it than to erect a D.C. substation of equivalent capacity, provided the maximum demand on the network is less than 60 per cent. of the plant capacity of the centre. Where the maximum demand of a D.C. centre equals 75 per cent. of its plant capacity, the cost of doubling the capacity of the centre by installing A.C. plant and changing over the network, is little more than the cost of doubling the capacity by extending the building and installing additional D.C. plant and mains.

The capacity of a system can also be increased by erecting an A.C. centre and changing over part of the network instead of adding to an existing D.C. substation. The comparative costs depend upon the distance of the nearest high-tension cable from the site of the new centre, and upon the expenditure necessary for low-tension cables. Usually, it will be found much cheaper to install the A.C. centre and to change over. Small townships at present generating direct current for their own use have an additional inducement to change their supply to alternating current. In all likelihood their plant will be shut down in the near future, and they will receive supply from the national "grid." If D.C. distribution were to be continued the cost of the necessary transformers and converting plant would be borne by the Central Electricity Board, but if it were decided to change the supply to alternating current nearly the whole of the estimated costs of transformers and converters necessary for continuing D.C. supply might still be obtained from the Board and used towards the cost of changing over.

For obvious reasons the only A.C. systems considered are the three-phase, four-wire system with pressures of 400 volts between phases and 230 volts from phase to neutral, and the single-phase three-wire system with 460 volts between outers and 230 volts from phase to neutral. The former will be referred to hereafter as the "standard" system, and the latter as the single-phase system. The "standard" system is undoubtedly the better one, and its advantages have been fully discussed in a previous paper by Messrs. Beard and Haldane.† Unfortunately, owing to the presence of a large proportion of three-wire mains in the majority of D.C. systems, financial considerations compel consideration of single-phase distribution. From an engineering point of view the single-phase system has certain disadvantages when compared with the standard system, but the great advantage in its use is that existing three-core cables can be fully utilised and the only new mains required in changing an area over are those necessary for development. The problem, therefore, becomes a dual one of engineering and finance, and it may be necessary to compromise by changing from D.C. supply to single-phase distribution with a view to a "standard" A.C. system at a later date. In the opinion of the authors, therefore, in changing from D.C. supply to A.C. distribution there are three alternatives, viz.: (1) Change-over to a "standard" A.C. system of supply; (2) change-over to a single-phase system of supply; (3) change-over to a temporary single-phase system of supply.

The reduction in maintenance charges on static substations compared with rectifier or rotary substations requires no explanation. The smaller costs for mains and services are accounted for by the freedom from electrolysis on an A.C. system and the large reduction in the number of faults. Records kept over a period of years show the average number of low-tension mains faults per 100 miles of distribution per annum to be 10·8 for a D.C. system and 0·99 for an A.C. system, and the average number of service faults per 1000 services per annum to be 1·7 on D.C. supply and 0·1 on A.C. supply.

The life of a low-tension network depends to a large extent upon the nature of the soil in which the cables are laid. As a matter of general practice the Electricity Commissioners, in the case of municipal undertakings, allow twenty-five years for loan repayment on low-tension cables, and if this term be accepted as the period of useful life—free from continuing faults—of a D.C. network, the life of an A.C. system, under similar conditions, would probably be in the neighbourhood of fifty years. Hence, an undertaking employing a D.C. system would, in all probability, be faced with the necessity of whole or part renewal of its network at the end of the period referred to, whilst the useful and free-from-trouble life of an A.C. network, under the same conditions, could safely be calculated to continue for a further twenty to twenty-five years. The financial advantage is apparent, and a change-over from direct to alternating current would undoubtedly, after a number of years, result in a large reduction in the capital outlay of an undertaking. Also, the life of transforming plant would probably be more than double that of rectifying plant.

It is interesting to note that some eight years ago a supply undertaking in the North Midlands was faced with the entire replacement of a large section of their D.C. network. In 1924 this section was changed over to alternating current and at the present time is giving complete satisfaction. In this case the total cost of the change-over was much less than the estimated cost of replacement, and when the change-over was completed the advantages of reduced maintenance and development charges were obtained. While the area was on the direct-current system, faults were constantly occurring, but since the change-over faults are practically unknown.

To summarise the economic advantages of change-over:

(*a*) *Maintenance and Repairs.*—The annual reduction in maintenance charges forms approximately 3 per cent. of the total cost of changing over.

† *Journal* I.E.E., 1927, Vol. 65, p. 97.

(*b*) *Development.*—On the basis of an annual increase of load of 15 per cent. the total cost of changing over should be recovered in approximately five years from development charges alone.

(*c*) *Increased Life of Networks.*—The reduction in capital expenditure due to the increased life of a network is important, as, in many cases, the price at which the unit of electricity is sold is considerably affected by the annual charge for interest and loan repayment on the capital invested in low-tension cables and plant.

Any one of the above advantages is almost sufficient to justify changing over, and when they are considered collectively there would appear to be no doubt as to the economic advantage of changing over any suburban or residential area.

Change-over in Industrial Areas and in Heavily Loaded City Areas.

The advantages claimed for A.C. distribution in suburban areas also apply to industrial and city areas, but in giving supply to the latter there are certain disadvantages which are not experienced in supplying the former. At present the majority of A.C. motors connected to a system are of the induction type. These motors, especially when running under their rated output, require from the mains a wattless kVA, and where the proportion of motor load is high this may necessitate the installation of power factor-correction plant. Fortunately, in many areas, a good proportion of the load is practically non-inductive and tends to minimise the effect of the wattless kVA due to motor load. Consumers are also becoming aware of the advantage of a high power factor, and some supply authorities are introducing preferential terms for good power factor. The result is that, in some instances, consumers are installing synchronous motors or other means of power factor correction, and, should this practice continue, difficulties resulting from a bad power factor will tend to diminish. Where power factor improvement is considered necessary, it is obviously undesirable to instal plant for this purpose at each distributing centre, and the authors are of the opinion that this problem should be dealt with from the high-tension side of a system by installing power-factor-correction plant at certain selected master substations. Comparing individual centres, however, the cost of an A.C. installation, including power factor-correction plant, is still much less than that of a D.C. installation of equivalent capacity. In some undertakings traction load supplied from rotary converters might be used, to some extent, for power factor improvement.

On heavily loaded D.C. systems, in the event of a failure of supply, secondary batteries can be used. On an A.C. system there is nothing to replace such batteries, and in the past this has been put forward as one of the chief objections to A.C. distribution. The initial and maintenance costs of secondary batteries are very high, and, under present conditions, it is doubtful whether their use is justified on a D.C. system, except under very unusual circumstances. On an A.C. system, hospitals, theatres, &c., could have duplicate services each supplied from a separate distributing centre. Standby supplies would thus be provided except in the case of a complete failure of the high-tension system, which, under present-day conditions, is a very remote possibility. In special cases a system of pilot lighting could be supplied from small private batteries.

The standardisation of low-tension distribution is even more important in industrial and city areas than in suburban areas, because of the greater amount of apparatus connected to the supply. The total cost of changing over would be greater than in suburban areas, but, due to the density of the load, the cost per kW based on maximum demand would probably be less. Where the growth of load necessitates an increase in the capacity of a D.C. system, if it can be shown that the increased capacity can be obtained by changing over to alternating current at a cost not greatly in excess of obtaining a corresponding increase on direct current, then there should be no question as to the advantage of changing over.

Owing to the type of load and conditions of loading, the single-phase system need not be considered for these areas. The number of motors of large output and the necessity for interlinking between all distribution centres makes the "standard" system, in the opinion of the authors, the only suitable means of A.C. distribution for industrial and city areas. Many large shops, stores, small factories, and large buildings containing numerous offices, are at present supplied from the low-tension D.C. system, and have a maximum demand varying from 30 kW up to, or even exceeding, 200 kW, and it is suggested that any consumer, or any building containing a number of consumers, having a maximum demand of more than 30 kW should be changed over to the high-tension supply. This transfer could take place gradually, starting with the consumers who take the heaviest load, and by this means the low-tension D.C. network would be relieved and enabled to deal with any increase in loads of smaller size. Heavy low-tension feeder losses would also be avoided.

Difficulties are likely to arise in obtaining sites for substations inside consumers' premises, but an A.C. substation, to give supply to one consumer, requires very little room. In the case of factories and workshops, when it is explained that the existing D.C. plant, which may be obsolete and inefficient, will be replaced by efficient A.C. plant, and that the maintenance charges on the latter will be very much less than those on the former, the consumer would usually find room for a substation, and might even be persuaded to pay part of the cost of changing over. Opportunities would also occur to transfer D.C. installations to the high-tension supply when consumers wished to increased their load.

When the increase in low-tension load exceeded the relief obtained from the transfer to the high-tension system, a change-over of small sections of the D.C. network to standard A.C. supply could take place. Gradually, the load on the peripheries of the areas supplied from D.C. substations could be transferred to alternating current. The radius of supply of D.C. substations would thus be reduced and D.C. feeders could be reduced in length and so enabled to deal with increased demand on that portion of the D.C. network nearer the substations. A reduction in low-tension distribution losses and an improvement in voltage regulation would thereby take place.

It would be unnecessary to increase the D.C. converting plant or to lay any additional low-tension D.C. feeders and as the existing converting plant required replacement the A.C. distribution could be extended and the D.C. system reduced, until finally a complete "standard" A.C. system would be obtained. The majority of industrial and city areas have been well developed electrically for a considerable time, with the result that, where the supply is direct current, a very large proportion of the mains are three-wire. Many of the existing D.C. feeders consist of three single, lead-covered, armoured cables of 1 square inch, 0·5 square inch, 1 square inch cross section, and, due to sheath and armour losses, it would be impossible to use these feeders economically for any type of A.C. supply. The existing three-wire distributors could not be used on two phases and neutral, because of the nature of the load and the density of the loading. Therefore, before changing over a section of an industrial area to alternating current it would be necessary to replace nearly all the three-wire mains in the section with four-core mains, or to superimpose a new four-core network on the existing three-wire network.

An area remaining on direct current requires new cables to replace old and to supply new consumers. If all these new cables were four-core it would materially reduce the cost of change-over. It would also be an advantage if all new power consumers could be prevailed upon, as far as possible, to install wiring and switchgear suitable for three-phase supply. Should a high-tension supply in any area be of a periodicity other than 50 cycles per second, it might be necessary to lay new low-tension feeders to meet the increase in D.C. load until the standardisation of frequency made it possible to relieve the low-tension network by transfers to the high-tension system. As already mentioned, a type of feeder very often used in heavily loaded D.C. areas consists of three single, lead-covered, armoured cables. Instead of laying this type of feeder, a number of four-core cables might be laid from the substation to the feeding point, each cable by a different route. By this means a four-core network suitable for A.C. supply would be built up.

The authors have not at their disposal sufficient information to enable them to put forward actual costs for changing over in industrial or city areas, but although the cost per square mile would be very much higher it is not anticipated that the costs per kW, based on maximum demand, would exceed those for suburban areas.

The authors are of the opinion that their investigations indicate that not only are engineering and technical advantages to be derived from a change-over to low-tension A.C. supply in suburban, industrial, and city areas, but that a change-over in these areas is essential for economic reasons.

The expenditure necessary for change-over and development must vary, owing to local conditions, and must depend upon the type and density of the load, the type of plant and apparatus installed, and the engineering practice adopted, but it is not claimed that the various costs put forward in the paper would apply to all supply undertakings or to any one undertaking. These costs are for comparative purposes only, and, although they are only approximate, an endeavour has been made in all cases to maintain a just comparison, and the authors feel that sufficient accuracy has been obtained to show clearly the financial advantages to be derived from changing over in any area.

It has been assumed that the D.C. voltage prior to a change-over would be sufficiently near to the "standard" A.C. voltage to obviate the necessity of altering any apparatus because of an alteration in the voltage of the supply. The problem of the standardisation of voltage has been fully dealt with in a previous paper by Messrs. Beard and Haldane,‡ and the present authors are most decidedly of the opinion that where a change of the system of supply takes place, only the "standard" A.C. voltage of 230 volts between phase and neutral should be adopted.

The advantages to be obtained from a change-over from low-tension D.C. supply to low-tension A.C. supply would appear to compare favourably with the benefits which, it is claimed, will be derived from the national standardisation of frequency, and the authors are of the opinion that the standardisation of low-tension distribution is also a national rather than a local problem.

In the operation of remotely controlled motors the electrostatic capacity of the control circuit may, says Mr. A. C. McHugh, in *Power*, cause faulty action of the motor's starter. A case of this kind recently came to the attention of the writer. A 50 H.P., 440-volt, 50-cycle motor, driving a centrifugal booster pump supplying water to a storage tank approximately one mile away, was to be controlled by a float switch on the storage tank. Two No. 14 wires with a lead covering, installed in a ¾in. conduit, ran from the tank switch to the motor starter. It was found that closing the tank switch would start the motor, but opening this switch did not demagnetise the starting contactor's holding coil. A voltmeter test at the starter showed 440 volts at the coil terminals with the float switch closed and 285 volts across the coil with the switch open. The two control wires, being close together under the lead covering, formed a fairly good condenser and allowed sufficient current to flow to hold the contactor closed when the float switch was open. A bank of lamps was connected across the line at the starter, and by changing the size of lamps a proper shunt resistance to overcome the effects of the control line's electrostatic capacity was determined. Then a resistor coil of approximately the same resistance as the lamps was wound and installed across the line near the starter. This solved the problem, and now the control circuit operates satisfactorily. The pump is an important part of a domestic water system. In order that its operation may be observed a flow meter of the electric recording type was installed in the pipe line, and the integrator and recorder placed in the boiler-room so that the firemen are able to check the amount of water pumped, as well as the rate of pumping, in gallons per minute.

‡ *Journal* I.E.E., 1927 Vol. 65, p. 97.

L.N.E.R.—Romford Widening.

As a result of the rapidly increasing development of the district round Romford, which is served by the L.N.E. Railway, it was decided that a widening should be put in hand which would provide for extra lines and enlargements of the existing stations at Romford and Gidea Park. Particulars for this work were prepared and a contract known as the "Romford Junction to Romford Factory Widening" was let in January, 1930. The widening began at a point about 30 chains west of Romford Station, where the existing four lines of track converged to two lines, and ended at about 54 chains east of Gidea Park Station, a total length of about 2¼ miles.

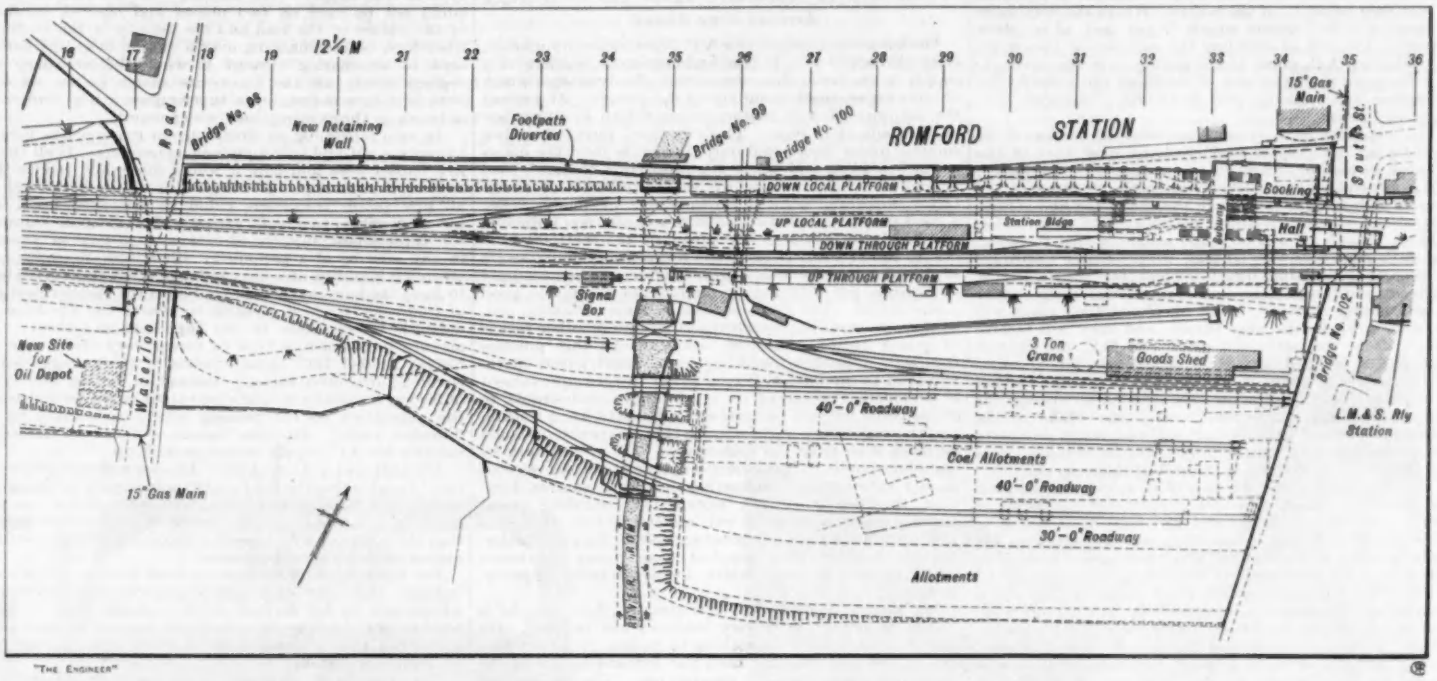
Before the alterations were carried out Romford Station consisted of Up and Down platforms, with the buildings on an embankment, and inclined footways on each side of the railway served as approaches to the station. The platforms were 500ft. in length and the railway was crossed by a footbridge to give access from the Down platform to the adjacent L.M. and S. Station. The reconstruction of the station was an important part of the widening. As now completed the station consists of four platforms, 600ft. in length. The old Up and Down platforms, which have been lengthened, now serve the "Through" or Fast line traffic, and two new platforms have been placed on the Down side for Up and Down local services. A new booking hall, giving ample accommodation and provided with passimeters with an entrance from South-street, which runs under the railway, has been constructed immediately under the widened lines. Two staircases, each 10ft. wide, lead from the booking hall to a distributing subway 15ft. wide and 11ft. 6in. above the floor level of the hall. From this subway stairways and inclines give access to the four platforms, the stairways being for passengers and the inclines for luggage barrows. The hall staircases, subway and inclines are lined with glazed bricks. Ample waiting-room accommodation is provided on the platforms, which are covered to a large extent with glass awnings. The booking hall and station buildings are in red brick externally with stone facings.

The retaining wall, which formed one side of the booking hall, and which was constructed next the existing railway, called for great care in execution, as the back of the wall was close to the existing Down line, the height of the wall being 28ft. As a preliminary, pressure piles were put down from the platform level, and as the excavation, which was carried out in short lengths, proceeded, these piles were bared and built into the solid brickwork. Temporary booking and parcels offices had to be constructed in order that the ordinary business of the company could be carried on during the time between demolition of the old and the completion of the new buildings. This and contingent temporary work caused little or no interference with the travelling public using the company's station.

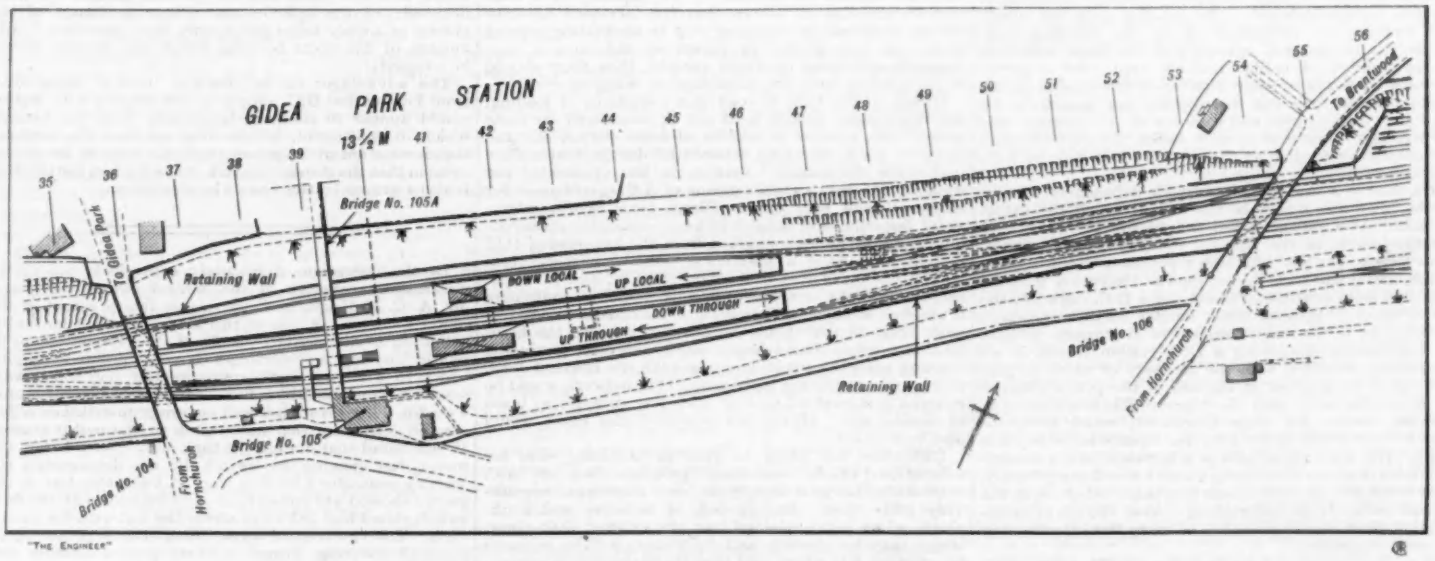
The retaining wall on the northern side of the station was built to a different design from the usual solid type, as, in addition to supporting the railway, it had to carry the Down platform serving the local lines. A recessed retaining wall was, therefore, adopted, with piers and arches backed with concrete, thus enabling the platform wall to be built immediately on it. Other works involved were the lengthening of the underbridge over Waterloo-road and its reconstruction from 18ft. span to 45ft. The old brick arch has given place to a steel plate girder bridge, and the cast iron girders carrying the incline to the lower goods yard level have been displaced by a similar steel girder bridge. South-street Bridge was also widened from 25ft. to 60ft. and reconstructed, the old arch being removed and replaced by a steel bridge with cross girders and plate floor. An additional bridge of the same type was also built to carry the Slow lines over the road and the booking hall.

In order to facilitate the reconstruction of South street and Waterloo-road bridges under the running lines, that part of the station, including the new bridges, required for the local traffic, was first built and when completed the main line traffic was diverted over this new portion, thus throwing the existing bridges into disuse and permitting them to be dealt with. The lengthening of the underbridge over the river Rom and of an arched bridge over a siding to a brewery, were necessitated by the station alterations, and three single-line bridges in steel were built over the same river south of the railway to give access to the new Goods and Coal Yard, where three additional loading sidings, each of thirty wagons capacity, are provided, together with carting spaces and coal-stacking areas. The abutments and wing walls of all the bridges are of concrete faced with brick well bonded into the concrete.

For the first three-quarters of a mile the widening is on embankment and has necessitated the construction of heavy retaining walls throughout that length. These walls are build of concrete with blue brindled brick facing and are provided with expansion joints at every 100ft. Between Romford Station and Gidea Park Station a footbridge was lengthened, the abutments of an overbridge close to the second-named station were underpinned and small retaining walls were constructed. At Gidea Park Station, where two island platforms already existed, the platforms were slightly readjusted to make them fit the re-alignment of the new permanent way. An overbridge east of this station, carrying Brentwood-road, consisted of one double-line opening and a single-line opening on the Down side. This single-line opening had to be replaced by a double-line opening, with an elliptic arch similar to the larger opening. As the original bridge was constructed somewhere about 1840, great care was needed to prevent settle-



MAP OF THE ROMFORD STATION DISTRICT AFTER COMPLETION OF THE WORK



MAP OF GIDEA PARK STATION DISTRICT AFTER COMPLETION OF THE WORK

ment in the old arch, and as the angle of skew was 51 deg., heavy timbering was used and maintained until the new arch was turned and backed up for one-third of its height in concrete. On striking centres no settlement in either arch was observed. A heavy retaining wall was built on the Down side near this site in order to make room for extensive sidings and the erection of a signal-box.

The excavation in the cuttings was not considerable. Part of the spoil was required for the embankments, and the remainder was moved from the site to an old gravel pit, or was deposited elsewhere.

The widening was carried out expeditiously in thirteen months to the designs and under the direction of Mr. C. J. Brown, C.B.E., M. Inst. C.E., Engineer of the Southern Area of the London and North-Eastern Railway, and under the immediate supervision of Mr. R. F. Bennett, M. Inst. C.E., late Assistant Engineer for Construction.

The Contractors for the widening work were Sir Robert McAlpine and Sons, Ltd., and Hipperson and Son, Ltd., for the buildings. On page 396 we reproduce four photographs illustrating certain portions of the work in progress.

X-Rays in the Welding Industry.

By R. A. STEPHEN, M.Sc.

SINCE welding became an established practice in the engineering and boilermaking industries, many attempts have been made to discover a reliable and non-destructive method of testing the finished weld. Amongst the various methods developed, with varying degrees of success, are the acoustic, the electrical, the magnetic and the X-ray. Experience has shown that the most reliable of these non-destructive examinations is that in which X-rays are employed, as only by this means is it possible to detect and locate bonding errors, gas bubbles, slag inclusions, shrinkage cracks, &c., and thereby assess the probable quality of the weld.

In Great Britain the application of X-rays to industrial problems has been developed chiefly as a result of the pioneer investigations of Pullin[1] at the Research Department, Woolwich. In industry itself, however, prominent firms on the Continent, and particularly in America, have been in the forefront in adopting X-ray methods of investigation. It should be noted, however, that at the works of Messrs. Babcock and Wilcox, Ltd., at Renfrew, the first Philips shockproof mobile X-ray unit in Great Britain has recently been installed, and is shown in Fig. 1. In the writings of Barthke,[2] Kanntner and Herr,[3] Von Schartz[4] and Lefning,[5] the examination of welded seams is minutely discussed and information is freely given on the detection of errors. Again, articles which have appeared in the American journal *Machinery*,[6] and in *The Welder*,[7] show that in America testing by means of X-rays has found a large field of application. For further information reference to Glocker[8] should also be made.

The use of gamma radiation has also been put forward for the testing of welds, but the radiographs so obtained lack contrast, with the result that the finer details are absent. Moreover, large quantities of radium are necessary and the exposures are of very long duration. Except for the examination of steel from 3½in. up to about 10in. in thickness, the use of gamma radiation is impracticable.

It is generally admitted that the X-ray method is the most satisfactory at present, but the difficulties and dangers associated with the high-voltage apparatus required to generate the X-rays of high penetrative power and the danger to which operators have hitherto been exposed from unwanted X-radiation have materially retarded its adoption. The bulky X-ray installations previously available required skilled *personnel* for their operation, and were invariably unsuitable for transportation. Long exposures were also necessary. As the result of the development of shockproof X-ray tubes in the Philips research laboratories, a new "Metalix" industrial X-ray unit has been introduced, which combines absolute electrical safety with the self-protection of the "Metalix" tube against unwanted radiation. The X-ray protection afforded complies with the recommendations of both the International and the German Committees on Protection, so that, in effect, only the useful beam emerges from the X-ray tube. It is claimed that the "Metalix" self-protected X-ray tube has solved the problem of protection in the medical applications of X-rays, and that in addition to the self-protected property, the shockproof feature of the new type "Metalix" tubes has completely eradicated the dangers due to high tension—a problem of no small difficulty for such high voltages as are necessary in the science of radiometallography. The shockproof construction of the X-ray tube and cables has permitted certain operations hitherto thought to have been beyond the reach of X-ray examination.

FIG. 1—X-RAY EQUIPMENT SUSPENDED FROM CRANE

Three factors have contributed to a reduction in the exposure times, viz.: (1) an increase in the energy input to the X-ray tube made possible by forced pressure cooling of the anode; (2) the "line" focus by which the area of the target bombarded by the electrons is greater than the effective optical dimensions of the focus, and (3) the development of special fast intensifying screens for short wave lengths. The reduction of the exposure times is of great interest as one of the previous objections to industrial applications of X-rays has been the uneconomical duration of the exposure periods.

The purpose of this article is briefly to describe some of the work on welded vessels which has been carried out with the Philips shockproof industrial X-ray unit. Fig. 2 shows the apparatus being used for the examination of the longitudinal seam of an all-welded marine boiler; and in Fig. 3 a tube is seen being used on the fire-box shell of a vertical cross tube boiler, the beam being directed at 45 deg. to the surface of the weld in order to determine whether errors detected in a previous radiograph were of a serious imperfect bonding nature.[8] The illustrations Figs. 4 and 5 are of exceptional interest, as they show the method of examining the longitudinal seam of a cross tube of the fire-box shell of Fig. 3, the X-ray tube being inserted in the cross tube itself, a method of examination made possible by the shockproof development.

The welds shown at A and B in Fig. 6 look very good, the small pores typical of electric welds—which can hardly be avoided—are of very small dimensions. In these pictures lighter parts correspond to thicker portions of metal, the parent plate coming out black, *i.e.*, the seam with reinforcements is thicker than the parent plate. It is possible to examine every type of seam, as the tube can easily be adjusted to fire in any direction desired, so that there are no awkward problems regarding the positioning of the object. As there is no need for a skilled operator, running costs of such an installation are extremely low in proportion to the value of the information afforded. At the side of the welds shown in Fig. 7, A, B and C, can be seen a comparative blackening scale, which results from a step ladder arrangement of iron, each step differing from the next by 1 mm. This step ladder is radiographed at the same time as the plate and acts as a reference scale from which the dimensions of flaws can be estimated in directions perpendicular to the incident X-rays. The weld shown in Fig. 7 A, from the X-ray evidence, appears to be sound. The weld shown at B is not as good as that in Fig. 7 A. Blow-holes, slag inclusions (1–12) are present, while a light line between *a* and *a* shows that the welding material has not joined on to the parent plate at the bottom of the vee. Judged by the reference scale the weakening is of the order of 1 mm., and the weld is still 3 mm. thicker in the seam than in the plate—from such indications experts can, therefore, form an opinion of the strength of the weld. Fig. 7 A is a positive copy of a V weld in a ⅜in. steel plate; as the seam with reinforcement is thicker than the parent plate, on a positive copy, dark portions represent the thicker parts of the specimen. Fig. 7 B is a positive copy of a V weld in mild steel made with an alloyed electrode-plate thickness of 1 1/16in., the thickness of the seam being about 1¼in. In Fig. 7 C, which is a positive copy of a radiograph of a ⅜in. plate, small blow-holes typical of electric welds are present, as well as small bonding errors.

The above method of estimating the dimensions of flaws is not applicable when the seam and reinforcements have been machined down almost to plate thickness. In this case a different method is adopted, which yields a similar result. An iron plate, previously examined by X-rays and found to be free

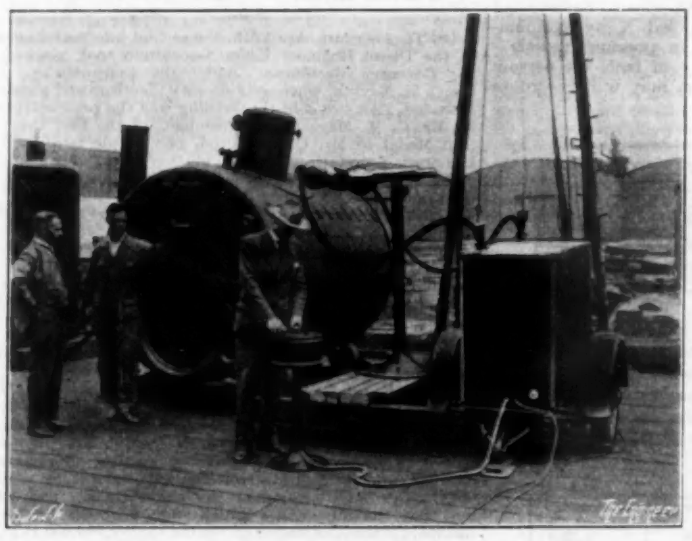


FIG. 2—X-RAY APPARATUS IN USE ON WELDED BOILER SEAM

FIG. 3—X-RAY TUBE IN USE ON FIRE-BOX SHELL

[1] Pullin and Wiltshire, "X-Rays, Past and Present"; Pullin, *Mechanical World and Engineering Record*, Jan. 16th, 1930; Pullin, THE ENGINEER, Feb., 1930, July, 1930.

[2] P. Barthke, International Congress for Welding Technic, the Hague, July 1st to 3rd, 1931; K. L. Zayem, Die Warme, 54, 329, 1931.

[3] Kanntner and Herr, Rontgenstrahlen in der Schweissindus. trie, Ztf fur Eissenbahnwerk, 1927, Nr. 22.

[4] M. V. Schartz, Ergebnisse der Tech. Röntgenkunde I., II. Akademische Verlagagesellschaft M.b.H. Leipsig, 1931.

[5] N. Lefning, Ergebnisse der Tech. Röntgenkunde II., page 313 (see [4]).

[6] C. O. Herb, *Machinery*, 37, 334, 1931.

[7] Isenburger, *The Welder*, August, 1931.

[8] R. Glocker, *Materialprufung mit Rontgenstrahlen*, page 70, 1927.

from flaws, has milled in it a number of steps, each differing from the next by 1 mm. This plate is placed on top of, and radiographed at the same time as the weld. The blackening reference scale is registered on

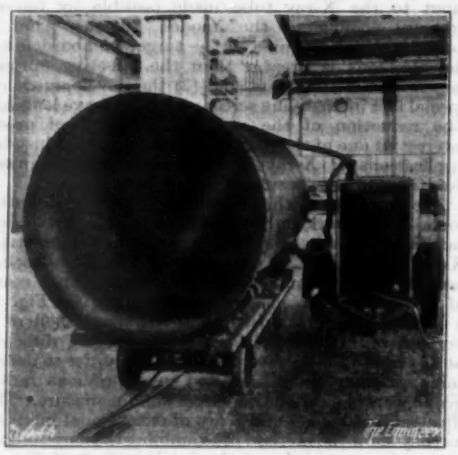
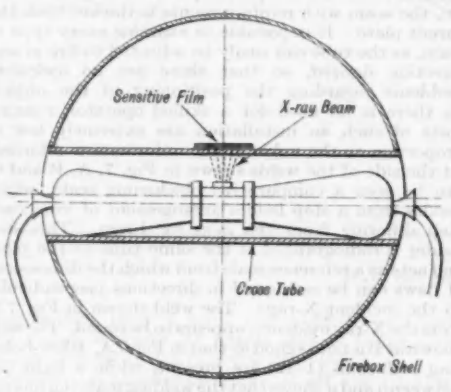


FIG. 4—X-RAY APPARATUS IN USE ON CROSS TUBE OF A FIRE-BOX SHELL

the film, and the dimensions of flaws in the direction of the incident rays is then estimated in the usual way.

By reason of its robust and compact design, it has been found possible to mount the industrial unit



SECTIONAL VIEW OF FIREBOX WITH CROSS-TUBE

"The Engineer" Swain Sc

FIG. 5—X-RAY TUBE INSIDE CROSS TUBE

on a small trailer so that, in addition, the obvious advantages of mobility have been obtained. The feature of mobility is of great interest. Thus, in the case of branch works, the duplication of equip-

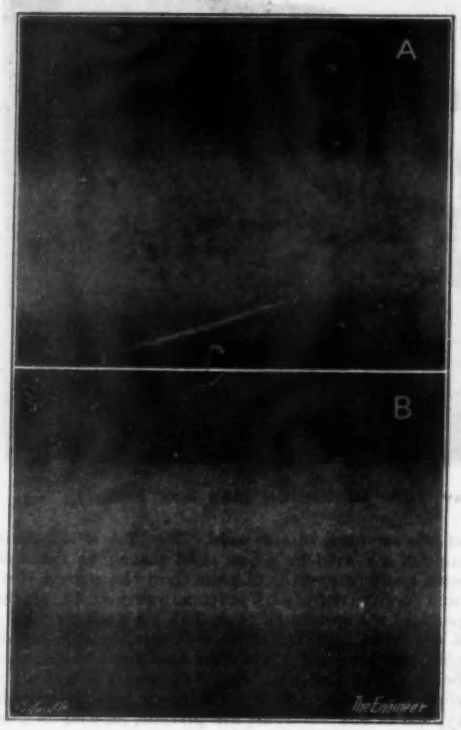


FIG. 6—BOILER SEAM WELDS

ment is unnecessary unless a great amount of work is to be done at both.

In certain cases, for instance in a dockyard, it may not be quite practicable to take the trailer into position for an X-ray examination. In such an event, by means of tackles, the whole H.T. unit can be lifted by a crane to the position desired—the robust nature of the unit and tube makes this possible. X-ray examination can, therefore, be carried out wherever a suitable electrical supply is available—220 volts, 50 cycles, 10–15 ampères. Fig. 8 shows the complete outfit arranged for transport with portable tube stand, control table, H.T. generator, X-ray tube and cables mounted on a trailer and protected by a waterproof cover.

As a control over the technique of welding, the X-ray method has proved its utility. Trial plates welded with different electrodes and under different conditions, *e.g.*, current density, rate of feed, &c., can be radiographed and the result compared with the mechanical data; in this way methods of fabrication can be improved and standardised.

The fact must not be missed that the Boiler Code Committee of the American Society of Mechanical Engineers has specified X-ray examination for certain welded joins in pressure vessels—this definitely shows the way—in fact, for certain welded joins X-ray examination may well become a

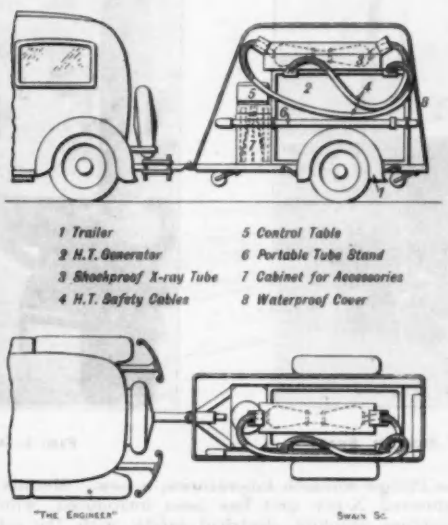


FIG. 8—X-RAY APPARATUS ARRANGED FOR TRANSPORT

matter of insurance in Great Britain as well as in the United States.

Perusal of the literature on industrial X-rays reveals many interesting applications, most of which have been recognised by manufacturers on the Continent and in America as being of great practical value.

X-rays have been used to inspect crankshafts, to examine welds in pressure vessels, valve stem bushings, aeroplane propellers, welded aeroplane struts and pipes, automobile axles and many other parts where the safety factor is of great importance.

Castings and forgings of new design can be tested by X-rays before much money and time is spent on machining faulty products.

Now that X-ray examination is available with safe and practical apparatus, and, in consequence of the rapidity of the development of welding generally, it is imperative that manufacturers in Great Britain should, in this matter, at least keep up with their foreign competitors. X-ray examination of welds, besides being of great technical utility, will provide the necessary added confidence to the buyers, and will do much to dispel scepticism of engineers and insurance companies concerning the strength of welded joints.

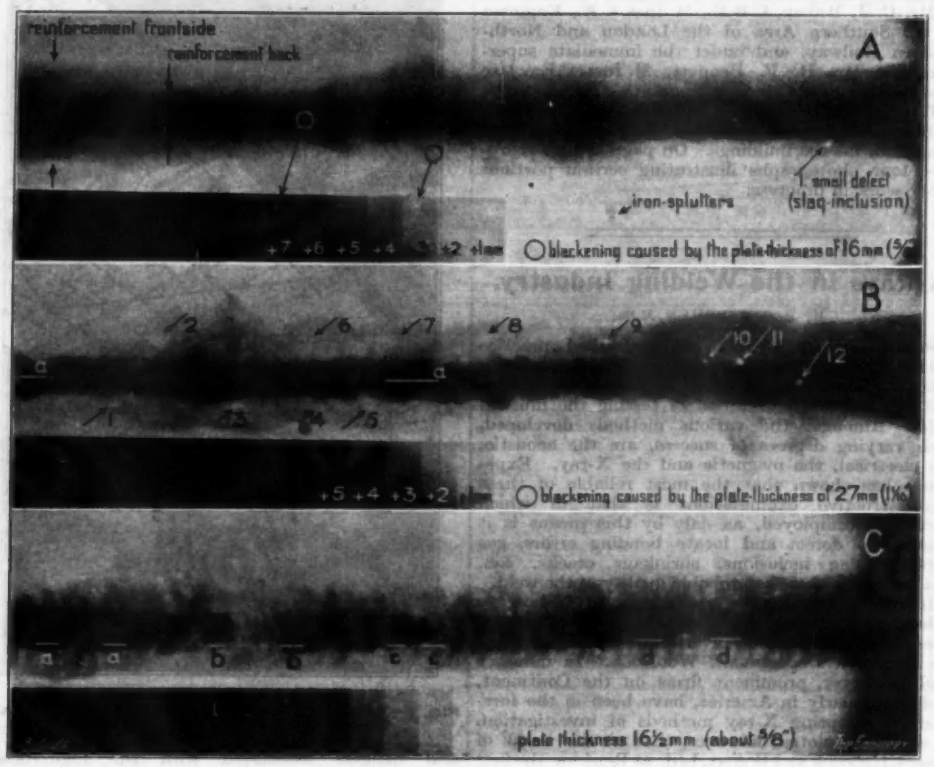


FIG. 7—RADIOGRAPHS OF STEEL PLATE WELDS

DIESEL ENGINE USERS ASSOCIATION.

On Tuesday last, April 5th, the second informal dinner of the Diesel Engineer Users Association took place at the Coventry Restaurant, under the chairmanship of Mr. C. M. Nayson, when over seventy members and guests attended. An event of the evening was the presentation by Mr. C. M. Mayson, the President, of the first Percy Still Medal to Mr. C. O. Milton, one of the two Joint Honorary Secretaries, for his valuable work, over many years, in the preparation of the annual reports on "Heavy-Oil Engine Working Costs." The toast of "Our Guests" was proposed by Mr. C. O. Milton, and in the absence of Mr. Percy Still, Mr. Richard Allen responded. In his reply, Mr. Allen made reference to the excellence of the Association's "Proceedings," which were, he said, outstanding by reason of their large-size drawings and the large clear type, two points which he strongly recommended to other institutions and scientific societies. He further spoke of the value of the work of the Association, which, he said, was being so ably continued by Rear-Admiral J. Hope Harrison. The question of "Proceedings" was also referred to by the President who advocated a standard size for all institutions, which he said should be as large as conveniently possible. In proposing the toast of "The Diesel Users Association," Mr. Charles Day gave some interesting figures concerning oil engines at work, and recalled some of his early experiences with slide valve and two-stroke gas engines. He pointed out that the oil engines which were operated by the members of the Association amounted to over 500,000 H.P., and they included fifty different types. Of such engines over 300,000 H.P. was at work in the British Isles, and these engines had yielded a valuable collective experience which, by the activities of the Association, had been taken advantage of to the full, alike by the makers and the users. The use of oil engines for the generation of electric power had been discouraged by recent Governments, in order to forward the "grid" scheme, but he was of the opinion that the economical working of oil engine-driven plants merited the careful and sympathetic consideration of the Electricity Commissioners.

In his reply, the President recalled the early work of the Association and regretted the unavoidable absence of Mr. Percy Still, whose work, he said they had endeavoured to make more permanent by the creation of the Percy Still Prize and Medal. The Association had, in 1917, 160 subscribers and eighty members, and in 1930 those numbers had risen to 500 and 230 respectively; they were still increasing. The toast of "The Honorary Officers" was proposed by Mr. W. A. Tookey in a happily conceived speech, and acknowledged by Mr. F. A. Greene, Treasurer, and Rear-Admiral Hope Harrison.

Railway and Road Matters.

THE Great Western Company hopes to open the diversions of the main line at Westbury and Frome in time for the summer train service. The purpose of these works is to avoid the present severe reduction of speed in express passenger and express freight trains owing to the sharp curves approaching and through those stations.

THE Southern Railway Company's Bill for providing a coaling plant for loading ships at Dover was read a second time in the House of Commons on March 1st, and referred to a Select Committee. It is likely, however, to be strongly opposed there by the local authorities, as it means the conveyance of coal wagons along the seafront, which, it is thought, would spoil the amenities of the town.

THE widening of the Great Western main line north and south of Taunton is now almost completed. It consists mainly of the conversion from two to four running lines between Cogload Junction—where the two main lines, *viâ* Bristol and *viâ* Westbury, join—through Taunton Station, to Norton Fitzwarren Junction, where the branches for Ilfracombe and Minehead leave the main line.

THE report for 1931 of the Metropolitan Railway shows that its gross receipts for the year were £1,564,811, and the expenditure £1,060,677; in 1930 these respective figures were £1,638,264 and £1,101,757; and thus the net receipts for 1931 were £504,134 as against £536,507. The Metropolitan District report records £1,470,865 receipts, £976,342 expenditure, and £494,523 net receipts. These compared with £1,464,893, £941,800, and £523,093 respectively in 1930.

IN a paragraph herein on March 4th we quoted what the chairman of the Southern Railway had just previously said as to privately owned wagons. The quotation in question included a mention of the views of the Standing Committee on Mineral Transport, and the query went through our mind at the time whether that Committee was still in being. That that is so has since been shown by the official announcement that the Minister of Transport and the Secretary of Mines have appointed Sir Henry Jackson to be the Chairman of the Standing Committee, in place of the late Sir Arthur Duckham.

THE first electric train from Maritzburg to Cato Ridge left on Monday morning, February 15th, at eleven o'clock, and represented the opening of the service. The time taken over this section is now reduced by approximately two hours in each direction, and in future all goods will be carried over the electrified line. When the scheme was first mooted an outside firm estimated that it would cost £389,000, but the Administration has been able to undercut this by £237,000. The work was done in the remarkably short time of eight months, the rate of construction being 5 miles a month, double that on the Glencoe–Maritzburg section. The main line involved is 27 miles in length, but 44 miles of line have been electrified.

THE chairman of the Great Northern Railway of Ireland, speaking on February 24th at the annual meeting of that company, referred to the strengthening of the Boyne Viaduct at Drogheda and the viaduct at Malahide. Both works will shortly be completed, and there would not after that be any remaining steel structure of any magnitude on the line which should require renewal for very many years. Orders had been placed for five three-cylinder compound locomotives in place of engines that were no longer fit for service. They would be more efficient than any at present in use, and it was hoped to have them on the road in the early summer when substantial accelerations would be made in the principal main line services.

THERE would appear to be a probability that the committee of railway and road interests, mentioned in our Seven-day Journal on March 25th, will have to be enlarged and not confined only to representatives of the railways and long-distance road hauliers. There was a debate in the House of Lords on this question on March 22nd, in which it was urged that local authorities should also have a voice in the matter. The Earl of Plymouth, Parliamentary Secretary of the Ministry of Transport, opposed the proposal. He said that the purpose of the committee was to enable the parties to the controversy to discuss with one another, and, if possible, to agree to facts as to whether taxation and regulations were fair as between road and rail. Later on in the discussion, Lord Plymouth agreed that local authorities, and not merely County Councils, should be consulted as to representation on the committee. Sir Arthur Salter has since been appointed the chairman of the committee.

SOME interesting facts as to the use of steel sleepers are contained in the annual report for the year ended March 31st, 1931, of the South African Government Railways. Following on experiments conducted over a number of years, the utilisation of steel sleepers in place of hardwood sleepers has been considerably extended on the S.A. Railways. At one time they were advocated only for branch lines, but, as their superiority became more apparent, their use was extended to other lines, and it is now the policy of the administration to use steel sleepers wherever practicable. Comparisons are given between European steel sleepers, imported jarrah and creosoted South African yellowwood. These figures show that the respective cost in fifteen years is 3s. 8d., 5s. 11d. and 10s. 7d. The use of steel sleepers cannot fail to advance the prosperity of the national steel industry of the South African Union. The remarks on this subject conclude: "In the past wooden sleepers were considered the ideal for railway tracks, but in the improvements effected recently in the design of steel sleepers and better packing of the track, the steel sleeper is gradually eliminating its wooden prototype on many railways. There are, however, problems still to be overcome. For example, the steel sleeper is unsuitable in coastal areas owing to the corrosive effects of the sea air; on electrified sections, where the track is insulated, it is imperative that the type of sleeper used be a non-conductor of electricity. Until such time as these and other obstacles are overcome the wooden sleeper must continue to be used on such sections of line."

Notes and Memoranda.

MANY ancient bronzes, after prolonged burial, have, according to Dr. Scott, in a lecture on the "Romance of Museum Restoration," at the Royal Society of Arts, but little, if any, metal left, having become a mixture of cuprous and stannic oxides. In spite of this, much of the original ornament in great detail remains.

IN an article in *Indian Engineering* of March 5th concerning the Sukkur Barrage, it is stated that an irrigation canal with a bottom width of 20ft. can be excavated by hand at a cost of from 2½d. to 4d. per cubic yard. Power-operated draglines have, in the majority of cases, considerably reduced these costs.

THERE is a paragraph in *Power* of March 22nd, giving some particulars of "Robertson-Bonded Metal," which has been investigated by the Mellon Institute of Industrial Research, Pittsburgh. It appears to be a composite laminated material of alternate layers of metal and felt, securely cemented together and impregnated with a corrosion-resisting liquid. It is said that the material can be readily worked by bending, drawing, &c., without destroying the bond.

A SPECTACULAR feat of wrecking was recently carried out at the Vickers works at Sheffield. For forty years there had stood in the yard a travelling crane capable of lifting 100 tons and measuring 85ft. high by 55ft. span. The crane weighed some 250 tons. It was obsolete and so was wrecked by Thos. W. Ward, Ltd., of Sheffield, by cutting out parts of the legs, replacing them with timber, and then blowing out the timber with explosives. The space available was very cramped, but none of the parts of the crane fell beyond 18in. of their anticipated position.

THE testing of broadcast receivers is much more difficult than testing other electrical appliances. It is possible to get definite results under definite conditions, but to use these results to compare the relative merits of receivers under widely different conditions is practically impossible. A paper, therefore, read before the Institution of Electrical Engineers by H. A. Thomas on the methods of testing radio receivers at the National Physical Laboratory should prove useful to both manufacturers and users of broadcast apparatus. A suggested specification of the requisite tests is given, together with the experimental results obtained.

"WE know," says Dr. E. R. Johnson, of Pennsylvania, "there are 3 million miles of highways in the United States, and 250,000 miles of railways; but perhaps we do not know there are about 700,000 miles of road surfaced so they can be used by automobiles and trucks. There are 128,000 miles, I believe, of concrete roads. The mileage of hard surface roads is not so significant as is its rapid increase. I am told that about 50,000 miles of streets and roads are being rebuilt or constructed each year, at a cost of nearly 2,000,000,000 dollars; so highway transportation is not only very extensive, but is also increasing year by year."

IN a discussion which was opened at the Institution of Civil Engineers by Mr. I. V. Robinson, on the quantity of heat rejected into the circulating water of power plants, Mr. Verity stated that with ammonia it was said that the pressure at a temperature of 400 deg. Cent. was only slightly above the atmosphere. A compound of zinc and ammonia was used with zinc as an absorbent for the ammonia after expansion in an ammonia turbine, the ammonia being regenerated from the compound under pressure in an evaporator. Full information did not appear to be available as to the behaviour of the various materials with which the ammonia came into contact.

THE automobile industry of the United States has, according to *Tin*, developed an entirely new use for tin. Forty per cent. of all the motor vehicles in that country are being fitted this year with cast iron pistons and these pistons are coated with tin. Details as to the method and the thickness of the plating have not yet been disclosed, but it is interesting to note that practically all the leading makes of cars, apart from Ford, are included in the list of those which have changed over to this new development in engine construction. The rapid and widespread adoption of tinned pistons proves beyond question that the tests have disclosed a marked advantage in actual use.

AT a recent meeting of the North Staffordshire Institute of Mining Engineers, and during the discussion which followed the reading of a paper on "The Production of Oil from Coal," by Professor A. W. Nash, Mr. Stuart Barber, President, said that he was rather in favour of exploiting our coal resources so as to make it possible for coal to do the jobs for which oil was at present used. There was a great future, in his opinion, for pulverised fuel. It was interesting to note that if all the petrol used in this country were produced from coal the increase in the consumption of coal would be only 6 per cent., or, in other words, between 13 and 14 million tons. This was less than three weeks' output for the country.

A PUSS MOTH aeroplane was, according to the *South African Mining and Engineering Journal*, put to a novel purpose over Johannesburg recently to test a Johannesburg man's ability to work at an altitude of 11,000ft. above sea level. It appears that the man in question has secured an appointment on the tin mines in Bolivia, which are worked at an altitude of 11,000ft. above sea level, and it was necessary to make sure that the applicant for the post could stand the high altitude. Dr. A. J. Orenstein, C.M.G., conducted the test. The applicant was taken up in a Puss Moth to a height of 16,000ft. above sea level—that is, 10,000ft. above the city. It took forty-five minutes for the machine to reach this height. At 16,000ft. it was very cold, but in the closed cabin conditions were comfortable, and the examinee was in no way affected by the altitude. His blood pressure was not seriously affected. The descent from this altitude took fifteen minutes, and on reaching the ground the examinee was subjected to tests by certain delicate instruments Dr. Orenstein had brought with him to the aerodrome. The test was satisfactorily passed, and the applicant has, it is understood, been certified medically fit for working on the tin mines.

Miscellanea.

IT is reported that the Soviet Russian Government has given an order for twenty-one newspaper printing machines to R. Hoe and Co., of London.

DEPOSITS of cinnabar ore, from which mercury is obtained, have been recently discovered in Pike County, Arkansas, covering a tract 22 miles long.

EXTENSIVE beds of unusually pure salt, several hundred feet thick, have been discovered near Nappan, Nova Scotia, in the process of drilling for oil.

COBALT ore is being shipped at the rate of about 100 tons a month, by air, from Werner Lake to the railway at Minaki, Ontario. The distance is about 40 miles.

THE centenary of S. A. Varley, who has been described as "The Father of the Dynamo," will be observed by the Institution of Electrical Engineers at a meeting in May next.

A FLOATING dock is to be built at Port-Glasgow, by W. Hamilton and Co., for service in South Africa. It has been ordered by the Crown Agents for the Colonies and will be 250ft. long.

IT is proposed to put up a refining works in Ontario for the extraction of radium from the ore coming from the Great Bear Lake deposits of pitchblende. There are already 20 tons of ore to work upon.

A GERMAN firm of safety razor blade manufacturers has opened a factory in Belfast. Premises have been secured in Albert-street, and manufacture has begun for the Northern Ireland and British markets.

AN American Society of Tool Engineering was formed at a meeting in Detroit on March 3rd to advance the knowledge of tool engineering. Headquarters have been established at 8203, Woodward-avenue, in that city.

WORK has been started actively on the resuscitation of the lead-mining industry of Flintshire, in the vicinity of Halkyn Mountain, near Holywell, and a new washing plant has been set to work. The industry is expected to employ about a thousand men.

IT is said that the iron ore concessions which have recently been secured by Japan on the upper reaches of the Muar River, which has its mouth on the Johore Straits, Malaya, contain tens of millions of tons of ore containing as much as 65 per cent. of iron.

ACCORDING to an Italian journal a Milan inventor has devised an aeroplane weighing ¾ ton and fitted with an 80 horse-power engine, which can rise from the ground in three seconds and attain a speed of 91 miles per hour. It is said that the gliding angle is 1 in 50.

A PAMPHLET giving the revised arrangements and conditions for the award of the National Certificates and Diplomas of the Institution of Electrical Engineers in conjunction with the Board of Education, has just been issued by the Board. It can be obtained from H.M. Stationery Office, price 1d.

THE Société Générale's report announces that the new copper basin discovered on the Katanga Railway, Central Africa, doubles the ore reserves, and adds that its working will be carried out in "particularly advantageous conditions." The report states, too, that the cobalt and radium reserves prove to be more and more considerable.

IN connection with the improvement of the Trent Navigation, between Birmingham and Hull, the ancient wooden bridge about a mile below Shardlow is to be demolished and replaced by a concrete bridge giving greater headroom. The old warehouses at Shardlow are also being modernised and provided with electric light.

IN the Don basin, Moscow, and other areas, experiments are, says the *British Russian Gazette*, now being carried out on the underground gasification of coal. A special Commission has been set up by the Coal Section of the Fuel Department to carry out investigations, and separate coal mines are being assigned. It is expected that the actual tests will begin early in 1933.

A FIREFLOAT has been put in service in New York which is equipped with five petrol engines, each of 550 horse-power. Four of these engines are connected to the pumps, which have a capacity of 16,000 gallons per minute, while the fifth engine is reserved for propulsion. The other engines can, however, also be used for propulsion, by an electric system, and give the boat a speed of 18 miles per hour.

THE new motor lifeboat which the Royal National Lifeboat Institution has built for its station at Weymouth, Dorsetshire, will be formally inaugurated on July 16th. Lord Shaftesbury, the Lord Lieutenant of Dorset, will take part in the ceremony, and Lady Shaftesbury will name the lifeboat. The boat is one of the largest and most powerful in the Institution's fleet. She is of the Barnett Stromness type, 51ft. by 13ft. 6in., with a displacement of 26½ tons.

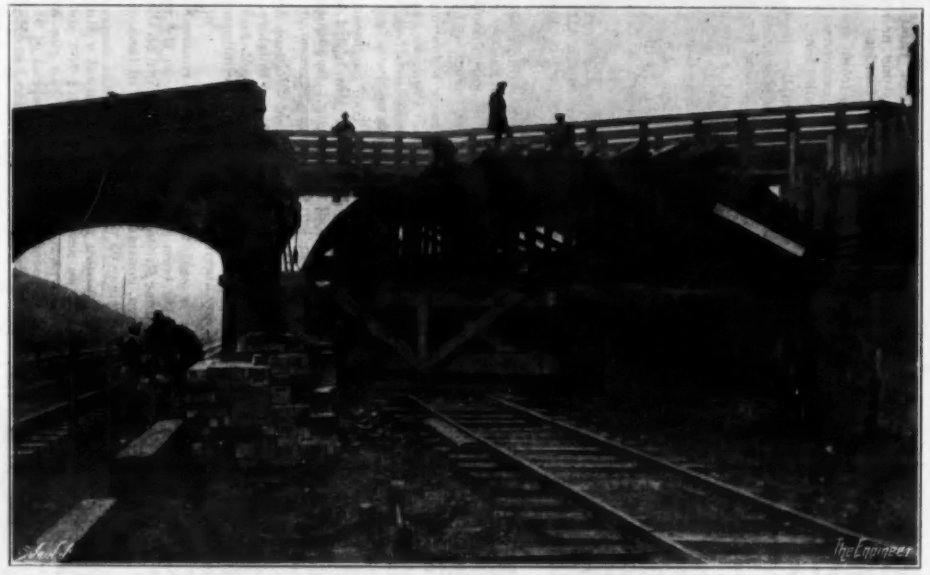
THE Chinese Ministry of Industry, says the *Far Eastern Review*, has announced that a 50 million dollar water power project near Ichang is to be constructed within three years. Mr. Chen Kung-po, the Minister has already authorised the construction of a 40,000 kW hydro-electric power plant at Ichang as part of the five-year industrial plan for the development of the Yangtze valley. According to experts the flow of water in the Ichang gorge was recorded as 800,000 cubic feet a second last October.

ACCORDING to the *Chemical Trade Journal*, the Orkla Grube Aktiebolag, the largest pyrites mining company of Norway, has recently put into operation a new plant for the production of pure sulphur from pyrites. This process, which is entirely the company's own development, is the result of ten years' research. The main reaction is carried out in four continuously working furnaces, in which the sulphur is liberated from the pyrites by the combined action of heating, oxidation with air oxygen, and reduction with carbon. The resulting products are sulphur, iron ore, and a minor quantity of by-products, chiefly thio-sulphates, which are gained from the waste gases. The capacity of the plant is about 200 tons of sulphur a day, or 70,000 tons annually.

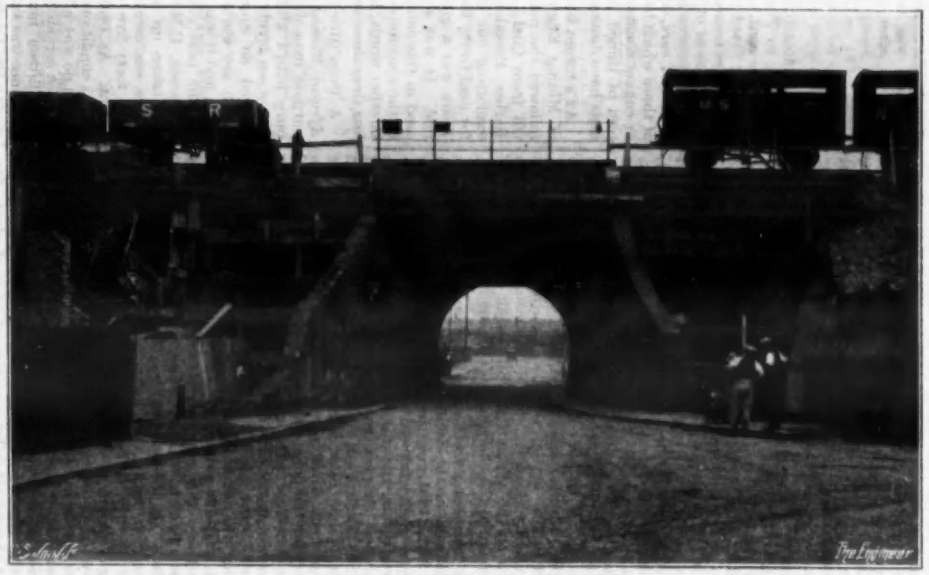
L.N.E.R. WIDENING—ROMFORD JUNCTION TO ROMFORD FACTORY

(*For description see page* 392)

BRIDGE AND BACK OF RETAINING WALL AT ROMFORD STATION



FORMING DOUBLE LINE OPENING OF BRIDGE NEAR GIDEA PARK



WIDENING OF WATERLOO ROAD BRIDGE

RETAINING WALL ON NORTH SIDE OF ROMFORD STATION

The Engineer

APRIL 8, 1932.

VOL. CLIII. No. 3978

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THE TESTING OF CASTINGS.

THE present age is marked by a spirit of inquiry which is no longer content complacently to accept the views and opinions of the past, but prefers to draw its own conclusions from its own immediate experiences—experiences which, in many respects, transcend entirely those upon which the older views and opinions were based. This is particularly the case in regard to the *criteria* of the strength of materials, and to the value and meaning to be attached to the various methods of testing applied to them in order to ascertain their properties and behaviour in that state of service to which it may please the engineer to call them. It is not, therefore, surprising to find that, quite apart from such considerations as those upon which theories of testing are based, or those relating to the standardising either of methods of testing or the shape or dimensions of the test piece itself, the attention of engineers and of metallurgists alike is being increasingly directed to specific tests of specific qualities not necessarily revealed by the ordinary routine methods of testing such broad and general properties as tensile—or compressive—strength, hardness, or impact resistance.

The testing of castings was, as our readers are aware, the subject recently of a full-dress discussion before the Institute of Metals. Despite the admirable opening address given by Dr. W. Rosenhain on that occasion, an address that covered practically every aspect of an exceedingly complex problem, but wisely left its possible solution to those who followed, the discussion can hardly be said to have achieved its object, presuming that to have been to elucidate the factors of the problem and indicate some mode of solving it. The discussion before the Institute of Metals bore, in the main, upon the testing of non-ferrous castings. From a wider point of view the whole subject of service tests had, a fortnight or so before, been dealt with—no less admirably—by Professor H. F. Moore, at the conjoint meeting in New York of the American Society for the Testing of Materials with other societies and institutes no less interested in the testing of materials. Dr. Moore, in his opening address, emphasised the highly important fact that the interpretation of an accelerated test is "always a matter of more or less uncertainty." He was speaking of wrought and not of cast metals—of metals, that is, which, as compared with castings, have at least the merit of being homogeneous, and of having been subjected, presumably, to the same mechanical and heat treatment throughout. We are far from saying that cast metals homogeneous throughout cannot ever be produced, or that, with care, their subsequent treatment may not secure a very high degree of homogeneity. On the whole, however, few will deny that in point of potential homogeneity a wrought metal must, almost inevitably, be superior to one which has been cast—a statement which holds good with peculiar force in respect of the metal most commonly used for the purpose of making castings, cast iron itself. Be this as it may, Professor Moore's warning applies to all metals and to all states of metals. The tests upon which the engineer has hitherto been taught to rely are, all of them, accelerated tests. Within limits they may give, just as the similar tests applied with the object of ascertaining the corrosion resistance of metals may give, a "figure of merit," which is some guide to their properties. Their interpretation, as Professor Moore pointed out, is nevertheless a matter of uncertainty. The above considerations apply to tests of wrought or of cast metals equally. A structure built up of wrought metals has the strength of its component parts, a strength which for most purposes can be fairly accurately ascertained by applying the usual methods of testing to all or any of the components. A cast test bar can on testing serve well enough to reveal the properties of the metal from which it has been poured. Such a bar, whether cast separately or cast-on as an integral part of a casting, can do no more, although on occasion it may do much less. It cannot, definitely, serve to reveal the properties of a "casting." Those depend on far more than the quality of the metal of which it has been cast. They vary from part to part of the casting; they depend not only on the skill of the designer and the knowledge and experience of the founder, but on fortuitous circumstances which are sometimes beyond the control of either. Not even the testing "to destruction" of the parts of a casting will necessarily reveal the strength or other service properties of the casting as a whole. It is plain, moreover, that to test a large casting to destruction is not within the bounds of practicable possibility. Yet even the testing of one of a batch of small castings, either to destruction or to any specfiic and more appropriate kind of test designed to simulate the service it will be called upon to give, and its satisfactory behaviour thereunder, can afford no definite guarantee that all the castings of the same batch will prove equally satisfactory. The engineer must, for the time being, be content with the presumption that, in such circumstances, all is for the best, and that most of the other castings will prove to be at least no worse than the specimen selected for test.

It is evident that the matter cannot be left thus, and that the engineer and the metallurgist must co-operate in devising more efficient modes for the testing of castings than are at present available, seeing that, somehow or other, tests of some kind need to be applied. They should be limited, to begin with, to the ascertainment of the specific properties which it is desired that a casting should possess—hardness, where hardness is required; density, when it is that property which, in service, may make or mar the casting; impact resistance or fatigue strength, when the stresses to which it may, in service, be subjected are of a nature to render such properties essential. In other words, the conclusions sought should not be derived from methods of testing which elicit properties other than the specific properties desired, however much tradition and custom may have led to the belief that there is some constant and necessary connection between them. We have to overhaul our old beliefs. But, above all, we need to devise new methods of testing. X-ray examination will help to reveal flaws; some serviceable tests for porosity already exist. With these and such new tests as the needs of the time and the ingenuity of the chemist, the physicist, the metallurgist, and the engineer, working together and with a common object, may succeed in devising, we may before long be able actually to prove our castings. At present we cannot. For the most part, we have to take them on trust.

Electrical Distribution.

WHILE most engineers now believe that a single system of electrical distribution would be advantageous, the pioneers held a totally different view. As a result, a state of confusion still exists in the electricity supply industry which will not be freed from the trouble by the standardisation of frequency. When the Government's scheme is complete in every detail there will still be D.C., single-phase and two-phase distribution systems, and different supply voltages. In their paper on "The Design of City Distribution Systems and the Problem of Standardisation," read before the Inst. E.E. in 1927, Messrs. Beard and Haldane suggested the three-phase, four-wire, 400/230-volt system as the most suitable standard, but whilst no unbiassed engineer can find fault with that system the trouble is the cost of introducing it in places where other systems are already in extensive use. Nevertheless, the authors expressed the view that more could be done than was commonly supposed in modifying and adapting existing systems, so as to achieve some of the main benefits of the method of distribution which they proposed. They considered that the advantages of standardisation were so great in the way of facilitating mass production that they ventured to suggest to manufacturers that it might be worth their while to co-operate with the electricity supply industry to establish standardisation. Apart altogether from the advantages of a common method of distribution, from the manufacturing point of view, it would also benefit the consumer. As it is, a consumer who has equipped his house with electrical appliances may find that they have become useless on transferring them to another part of the country or even to a different part of the same town. The proposed "standard" system is cheaper and more flexible than the D.C. system with its expensive converter or rectifier sub-stations, and it is a matter of regret that so much D.C. distribution still exists in this country.

The important matter of changing over low-tension D.C. systems to A.C. was again brought before the Inst. E.E. last week by a paper presented by Messrs. H. Blades and A. C. MacQueen, of Birmingham, where much work of this nature has been and is still being done. On the Birmingham L.T. system there are now approximately 60,000 A.C. and 58,000 D.C. consumers. The authors' investigations have shown that, irrespective of loading conditions, it is desirable to change-over residential and suburban areas at the earliest opportunity. Only in exceptional circumstances, they consider, should any additional D.C. plant be installed, and wherever possible the "standard" three-phase, four-wire system should be employed. The smaller cost of changing over from D.C. to the single-phase system, it is explained, is seldom justified, except for small isolated areas, where it should only be adopted as a temporary measure. But the conditions in industrial areas and heavily loaded city areas are rather different, and whilst the authors are equally emphatic about the desirability of introducing A.C., they point out that the change-over work must be done much more leisurely. For these areas in which there are large power consumers, the "standard" A.C. system is alone suitable. The three-phase motor is decidedly better than any single-phase motor for heavy industrial service. The authors advocate that the D.C. network should first of all be relieved by transferring, where possible, low-tension consumers with a maximum demand of over 30 kW to the H.T. supply. The consumer may wish to retain his D.C. motors or the supply undertaking may desire him to do so; then room must be found for a local rectifier or converter sub-station. On the other hand, the D.C. machines may be obsolete, and the installation of a complete new A.C. plant may be beneficial. When the increase in low-tension load exceeds the relief afforded by this method, it is proposed that a new four-wire network should be superimposed on the three-wire D.C. system, when a gradual change-over to A.C. would be made. No new D.C. plant should be installed, and as the existing plant requires replacement, the A.C. system should be extended and the D.C. system reduced. These, in brief, are the main conclusions at which Messrs. Blades and MacQueen arrive, and although there are bound to be some who will disagree with them, they will probably be endorsed by most engineers. As far as small townships and residential and suburban areas of a large city are concerned, there should be little, if any, objection to the authors' proposals.

As for the industrial and large city areas, the great obstacle is cost. Whether a change-over is justifiable, every engineer must decide for himself. No one, except perhaps the Electricity Commissioners, can see every engineer's difficulties or dictate to the industry as a whole. Still, the possibility of superimposing A.C. systems on D.C. systems does not seem to have received the attention it deserves. There has been a tendency, we fear, to perpetuate D.C. distribution because the

consumer has been deemed to need it. But if Birmingham and other equally important industrial areas can manage with A.C., it ought to be possible to make it suffice elsewhere. As Messrs. Beard and Haldane explained in their 1927 paper, the very few consumers who must have D.C. can always get it by local conversion, and they should not be allowed to affect the general decision. One of the conclusions which Messrs. Beard and Haldane reached was that the complete adoption of the standard system in any existing D.C. city area which they considered was impossible. In no case, where the D.C. power load predominated, was it found practicable to scrap the existing system entirely. On the other hand, they found that in any area where the power load was developing rapidly, it paid to superimpose a new standard system to deal with that load. But unfortunately this practice does not seem to have been adopted as widely as it might have been. The introduction of automatic sub-stations, and more recently mercury arc rectifiers, has probably encouraged some engineers to adhere entirely to their original method of supply. When it became necessary to shut down the old D.C. generating stations and to establish A.C. stations on more favourable sites, the converting business began, and it has gradually led to a state of affairs from which some undertakings would now gladly free themselves.

Shocks and Bridges.

Not very long ago we had to reprove the daily Press gently for the astonishment with which it greeted an advertisement asking for a man-eating tiger. We were then able to show that since immemorial times animals, birds, and even fishes had proved sources of inspiration to engineers, and that there was nothing in the advertisement calling for the extravagant comment it evoked. Our astonishment at the manner in which the daily Press plunges into technical details has since been further increased. A week ago paragraphs descriptive of electrical phenomena that had occurred upon the recently opened Sydney Harbour Bridge were inserted in a number of papers. Collectors on the bridge, it appears, have complained that, when receiving tolls from the occupants of motor cars, they frequently receive an electric shock. The journal in which we first noticed a paragraph recording these events offered an explanation that opens extraordinary possibilities to electrical engineers. Lest its full significance should be missed, we quote one passage in full:—"Electricity escaping from the batteries of cars is attracted on the ordinary highways by particles of dust, but in the dust-free air of the bridge the electricity becomes stored in the metal bodies of the cars and in the bodies of the passengers." The possibility thus suggested of converting low-voltage currents into high should certainly be investigated by electrical engineers. At present highly expensive transformers are necessary to perform this function, but if the conversion could be made in the way suggested by the passage quoted, immense savings might be made. We are not, of course, suggesting that the conversion should be brought about by "charging up" a series of cars at the terminals of an alternator and driving them across a suitable bridge at a rate calculated to bring about the correct rise of voltage to enable the vehicles to discharge to the line at the other end. Mechanical and electrical engineers, we trust, might be capable of producing some less expensive and more efficient mechanism. Since the paragraph explaining the events on Sydney Harbour Bridge seemed likely to cause comment, another of a confirmatory nature was inserted below it recording that a member of the journal's staff had received a perceptible electric shock when tipping the sleeping car attendant of a train in the Rockies of Canada. We commend this phenomenon to the Home Office for use in the suppression of secret commissions, and particularly to those who may desire to add another item to their array of arguments against tipping.

Railway Difficulties in South Africa.

How world-wide the depression in railways is, is shown by the conditions in South Africa. For the first two weeks of March the Union railway revenue was down £50,000 per week, as compared with the amount in the corresponding weeks of last year, and altogether the total revenue is computed to be about £2,000,000 less than in the year ended March 31st, 1931. How much of that drop has been offset by the frenzied rush to effect economies it is impossible to say as yet, of course, as the year has only just closed. There is no doubt that large savings have been effected, but at the expense of the standard of upkeep of permanent way, locomotives and rolling stock, wholesale dismissals of men, and placing of thousands on short time. Laid up locomotives and rolling stock are crowding workshops and sidings. The cost of bringing the railways back to their former efficiency will be enormous, but of this the Government is heedless, as it expects to be out of power before the day of reckoning arrives. The men in the railway workshops in Pretoria have recently been informed that in future work will cease at mid-day on Fridays. Further cuts in wages are also impending. In addition to the retirement of 2000 railway officials as redundant, the Government is rigidly enforcing its instruction that men of fifty years of age must be retired. Early in the year the Administration offered gratuities as inducements to men to retire from the service before reaching the pensionable age. So disgusted are the employees with the severe manner in which their earnings have been reduced that 5000 applications have already come in, and Government has the finding of a great sum for this purpose added to its many—and larger—financial embarrassments. This panic measure means that in the near future the Government will be placed in the inevitable position of being short-staffed, while, at the same time, it will have lost its experienced pioneers, who built up the service and are closely connected with all phases of railway business. The Rhodesian railways are also experiencing a very lean time, and have made application to the Railway Commission for increases in rates and fares to the extent of £145,000 a year.

Literature.

The Internal Combustion Engine. By D. R. Pye. Oxford: Clarendon Press. 1931. Price 15s.

Everyone acquainted with the work of Tizard and Pye on the process of combustion in the internal combustion engine will wish to read what one of these authors has to say on the general theory of this prime mover. Mr. Pye's book gives us this opportunity. We wish that for comparison we had one by Mr. Tizard, too. The same subject treated by these able investigators from their individual points of view would throw light from two angles and provide readers with an attractive perspective.

Mr. Pye gives us, not a text-book for students nor a manual for the manufacturer, but a skilfully prepared monograph on all the more important recent scientific work on the subject, presented not in encyclopædic form, but digested and regurgitated—if the author will forgive this—after much thought. The whole does therefore necessarily carry a deep impress of the writer's personality and of his attitude to practical problems. He points out in his preface that although one may set out to write a book on the internal combustion engine from two points of view, namely, to set down principles, or, alternatively, to supply information on practical details, the two aims do not combine well in one and the same book, and he thinks that the author who attempts to achieve completeness in both is likely to succeed in neither. The present book, dealing solely with the former, is expected to be primarily of service to the student, although the author does rather quaintly add that it should also be of service to the engineer "before he has become immersed in all the intricacies of manufacture"—though if the manufacturer is to profit at all by such a book, it would be more likely to be after he had realised what the practical difficulties were. Reading it before embarking on construction might even deter him from entering so thorny a field.

The order of treatment chosen for the subject matter is engine, cycles, fuels, detonation, combustion, thermal efficiency, and engine testing. Much is rightly made of the work of Ricardo—so much, indeed, that he has, in despair, to be omitted from the index entirely—and of Burstall. More perhaps might have been made of the very important work done a generation ago by Dugald Clerk.

A striking quality of the book is the detachment—almost aloofness—with which it is written. We are introduced to the ideas of volumetric heat and turbulence almost as though presented for the first time. Quantities of figures, either in the form of tables or curves, are given, with in many cases no suggestion as to where they came from or why or how the work was done. One seems to watch a graceful conjurer with an endless supply of quite magical rabbits. We catch the same point of view in the "octane number." It comes out of the hat quite suddenly, and innocent of any suggestion that the hatter was American.

On page 92 Mr. Pye makes a fair point against most preceding books on the subject on the ground that there is really little or no justification for the habit of drawing a distinction between the petrol engine and the Diesel cycle, as though it were a distinction between engines in which combustion occurs under conditions of constant volume and constant pressure, seeing that as the engines have developed in practice the real line of demarcation is between carburetter engines with spark ignition on the one hand, and high-compression engines with auto-ignition on the other. The author gives a good account of present-day views of the way in which oil is effectively burnt in compression ignition engines—the oil may be taken to the air, or the air to the oil; the aim may be to get a good distribution by violent and dispersive injection into relatively still air, which is difficult to achieve, or to swirl the air rapidly past the oil jet, which, as it happens, is much easier to do, especially when sleeve valves are used. It is, however, an odd thing that one may have so much air swirl in a carburetter engine that detonation may be facilitated. On the cause of detonation, the book has much to say, and the various theories, Callendar's and Egerton's, are fully discussed. This discussion includes the vexed question of the mode of action of the so-called "dopes," substances which, as the author amusingly puts it, have the qualities which enable their possessor to the high "distinction of being called a dope." Most people are fairly familiar with the wonderful effectiveness of tetra-ethyl-lead, but Mr. Pye elucidates the astonishing fact that this substance, on the basis of a 5 per cent. addition, is no less than 1000 times as effective as benzene. At the same time it has to be remembered that an aeroplane using this dope in a 500 H.P. engine on a 1000-mile flight would probably pass no less than 2 lb. or 3 lb. weight of metallic lead through the engine. If trouble is to be avoided, none of this must stay behind. Ricardo has warned us that trouble may also be encountered in any engine by unduly low thermal efficiency, since this must mean that the engine is turning but a low fraction of its heat supply into work, and that the heat it fails to convert is left over to be a nuisance. Mr. Pye quotes this same observer to the effect that of the many engines which pass his hands in the year, it is in every case the efficient engines which stand the endurance tests best, whilst the troubles due to gummed-up rings and burnt out valves are associated with the inefficient engines. The value of high efficiency is not that of saving a few shillingsworth of fuel, but the saving of many pounds worth of repairs.

So excellent is this book that we do not desire to stress the point that sometimes the argument verges on severity. For most of it is thoroughly readable, and readable not only with profit but with pleasure. We do doubt, however, the author's story of the satisfaction felt by a weak mixture on meeting a really fat spark, nor do we see why the calculations referred to on page 143 were not properly completed, as the author clearly shows how they could have been. Generally speaking, however, Mr. Pye has been meticulous in giving adequate time and attention to the necessary calculations, as is evidenced by the Burstall work cited in the footnote on page 107.

Although little reference is made to State-aided research, it is a fact that the most important work on the theory and development of the engine is wholly or partly subsidised. Among that wholly subsidised is the work at the Royal Aircraft Establishment, including the Farnborough indicator, so essential to the study of combustion, and no small portion of that done at the Ricardo works at Shoreham and in certain of the universities. Included in the partly subsidised is the wonderful work done at the Rolls-Royce works in the development of the engines used in the Schneider Trophy race, weighing even less than ¾ lb. per horse-power.

The author rightly stresses the importance when engine testing of taking "consumption loop" diagrams, namely, curve sheets showing the graph of fuel consumption per I.H.P.-hour against I.M.E.P. Mr. Pye points out that unless one knows the point on the consumption loop curve at which one is working in any particular experiment, the mere measurement of horse-power and fuel consumption may tell little or nothing about the economy of the engine. The only other guide is the colour of the exhaust port flames, but this calls for great experience, and not all engine designs lend themselves equally to it.

The book is welcome for its grasp of the essential purpose and meaning of recent research, and welcome, too, for its lucidity. Indeed, we should like to think that many of the newly arising generation of scientific engineers will command as felicitious a use of their mother tongue as does Mr. Pye, whose writing, whether on scientific or other topics, is worthy of unreserved praise.

Handbook on Technical Export. By Dr.-Ing. Kurt E. Lubowsky. Published by the V.D.I.-Verlag, Berlin. Price 42 Reichsmarks.

Every firm engaged in foreign trade must have had the annoying experience of receiving inquiries on which it is impossible to act without having some information that the potential customer has neglected to give. Even when the latter knows exactly what he wants he is liable to forget that the manufacturer has nothing but his letter to go on, and cannot be expected to know what is in the mind of his correspondent, nor to be familiar with conditions which the latter takes for granted. Inquiries received from the general agents through which a large part of the

trade with new countries is conducted are especially liable to be vague Such men handle everything that comes their way, and when to their technical ignorance of a specific subject has to be added, as is often the case, a confusion arising from differences of language, the result may be anything but enlightening to the firm whose "best price and delivery" are asked for. It is a fair assumption that Dr. Lubowsky, as head of the Overseas Department of the Allgemeine Electricitäts Gesellschaft, has suffered his full share of the worries due to incomplete or incomprehensible inquiries from abroad. If this be so, while charity would call for our sympathy, honesty compels us to confess our pleasure, for without such a stimulus he might never have undertaken the production of so eminently useful a work as the present volume.

The main object of the book is to enable any foreign agent or customer to send a complete and intelligible inquiry for anything of a technical nature that he may require, from a voltmeter or a pulley to a complete factory equipment. The index contains about a thousand references, each one designating a sort of questionnaire devoted to the particular subject. Turning to the page indicated, one finds a column of "reminders" usually condensed to a word or two, suggesting every fact that the manufacturer could want to know in order to be able to deal properly with an inquiry for the article or equipment in question. It would take far too much space to cite even a single example, but if the reader will note down every fact or condition that could be pertinent to an inquiry for some particular article he will have a good idea of the nature of this part of the volume. Moreover, if he will then check his list against that prepared for him, he is more likely than not to find out that he himself has been guilty of some more or less important omission, so difficult is it to remember everything in such a case.

We do not suggest that the book is perfect, but it is extremely good. To catch the author at fault is not easy, and numerous efforts to do so resulted in little more than finding no reference to the code of regulations enforced in the country for which a manufacturer may be asked to supply a steam boiler. On the other hand, the inquirer is reminded to mention the local regulations with regard to chimney height, and to the construction of industrial buildings. Occasionally the information to be sent to the manufacturer may be a little superfluous, as, for example, when it is suggested that a turbine maker need be told the price and calorific value of the fuel used. He would much rather know what kind of crane, if any, was available, a point which seems to have been overlooked. However, having been given the basement height, the quantity, quality, and temperature of the cooling water, and all particulars as to the duty and steam conditions of the proposed machine, the manufacturer would have little cause for complaint.

The subject matter, so far referred to, occupies about 600 pages, or something like two-thirds of the whole volume. The remainder facilitates the task of the estimator in a different fashion. It comprises tables of all the different currencies used by fifty-two countries, with the equivalents in U.S.A. dollars. Next comes a list of all the countries using the metric system of weights and measures, with indications as to those which use other systems as well, or prefer the British system. It is rather a shock to find neither Canada nor the United States included amongst those giving preference to British units, for the most casual reference to the technical literature of these countries would have put the author right on this point. Excellent conversion tables for all the primary and derived units used in engineering work are given. They are followed by notes on the effect of altitude on the performances of electrical machinery, high-tension lines, internal combustion engines, windmills, fans, pumps, and chimneys. To enable the home firm to know what altitudes and climatic conditions may have to be encountered, data relating to some 800 places from China to Peru are tabulated. These tables include heights above sea level, maximum and minimum temperatures and humidities, and the months in which they occur. Rainfall data are also included, and further tables give the differences in time, plus or minus, between any two of fifty-two different cities, a matter of convenience to senders of cables. The volume closes with an ingeniously tabulated statement of the patent requirements of different countries, an explanation of all customary abbreviations used by shippers together with the obligations which they involve, and lastly a list of "caution marks" for packages.

For the sake of clearness, one of the most important features of the whole book has so far not been referred to. This is the fact that it is printed throughout in four languages—English, German, French, and Spanish—so that it is equally useful in any country where any of these tongues is spoken. The respective languages are mostly arranged in four parallel columns, but when more convenient the tables and other data in each language are printed separately from each other. The English is admirable, technically and otherwise, and we only noticed one trivial misprint in the whole volume. Besides fulfilling its main object, the volume serves indirectly as a useful technical dictionary in four languages. We cordially recommend it to all concerned with international trade in machinery and apparatus, whether as agents abroad or as designers and estimators at home. It meets a great and growing need in the mechanism of commerce.

Modern Milling of Sugar Cane. By F. MAXWELL. London: Norman Rodger. 1932. Price 50s. net.

THE making of cane sugar divides itself into two distinct processes, the extraction of the juice from the cane, and its subsequent evaporation and crystallisation. Mr. Maxwell has confined himself to the first process in the present volume, and he is in a good position to discuss the subject, as he has been technical adviser to several important sugar concerns. The book starts with a brief description of the characteristics of sugar cane, in which the comparative difficulty of extracting the juice from the nodes and rind is emphasised—it requires 2000 horse-power to crush 3000 tons of cane a day. It then passes in review the various appliances used about a mill, such as cane unloaders, carriers, knives, crushers, and shredders. Here the author fully explains the modern tendency to prepare the cane for milling by a preliminary disintegration, so that the work of the rolls is concentrated on pressing the juice out of the mass. Some interesting illustrations are given of various forms of corrugations for crusher rollers. The next chapter is concerned with the mill itself, and the author describes a wide variety of designs both from this country and the Continent. He points out the variations in the design of housings made to suit the different methods of milling used in different countries, concentrating largely on Hawaii and Java, where milling has been developed to a very high degree, but he does not altogether neglect British practice, such as that of Queensland and Natal. Mill driving is divided into two chapters, one on steam engines and the other on electric driving In the latter the author discusses the relative merits of A.C. and D.C. drives. Imbibition—that is to say, the addition of water to the already crushed cane for the purpose of washing out the sugar—and maceration are dealt with at some length, and there is an important chapter on the control of milling operations.

It is a well-written and well-illustrated volume, of some 400 pages, which should prove useful to all those connected with the sugar milling industry.

SHORT NOTICES.

Brassey's Naval and Shipping Annual, 1932. Edited by Commander C. N. Robinson, R.N., and H. M. Ross. London: W. Clowes and Sons, Ltd., 94, Jermyn-street, S.W. 1. Price 25s. net.—The subjects dealt with in this well-known volume are of considerable importance and interest, as not only are sea affairs discussed by authoritative writers, but the conduct, progress, and efficiency of all war and merchant navies are closely surveyed. An innovation is a chapter dealing in a concise and practical way with the air arms of the four leading Naval Powers. The naval section includes the following chapters:—Naval Forces of the British Empire; Foreign Navies; Comparative Strength and Distribution; After the Treaty of London, 1931; The Accountant Branch of the Royal Navy; Recent Changes in Designs of Naval Guns; The Importance of Naval Reserves; Foreign Fleet Air Arms. Much interest will be found in the Merchant Shipping Section, subdivided as follows:—Standing of the World's Merchant Fleets; Old Ships and New Ships; State-owned Shipping; The American Merchant Marine; The Cunard Line; Bristol, Past and Present; Training of Cadets for the Merchant Navy; The Cost of Ships; Mercantile Marine Machinery; Notable Merchant Ships of the Year; On the Bridge of a Liner; Commercial Marine Aircraft. The remaining five sections are:—The Naval Reference Section; British and Foreign Ordnance Tables; Foreign Naval Aircraft Types; Merchant Shipping Reference Section; and a large selection of profiles and plans of warships and merchant ships. The book contains many excellent illustrations, and it is evident that, as in former years, the compilers have not spared any effort to produce a complete and comprehensive work, replete with valuable information.

The Mechanical Handling and Storing of Material. By G. F. Zimmer. London: Crosby Lockwood and Son. 1932. £3 3s.—This work has reached its fourth edition and is now published in two separate volumes, having altogether nearly nine hundred pages. It has been considerably improved by the author's overhauling. We have, for instance, noticed in past editions some slight inaccuracies, but these have been remedied and the book can be taken as a true account of the means used throughout the world for handling and transporting materials, with the exception, of course, of the actual transit operations of railways and road transport. Aerial ropeways are, however, dealt with, and the terminal facilities connected with both rail and road described at length. Mr. Zimmer's connection with conveyors is well known, and it is consequently hardly necessary to expand upon that part of the work devoted to that subject. Although the author has drawn his information from very widely divergent sources, we feel that one or two errors of omission exist, but it should be pointed out that the subject matter in the two volumes has required 1253 cuts for illustration. They are enlivened throughout by occasional historical references to quite distant dates. The book is not "trady" in the least and should prove very helpful to anyone confronted with a transport problem not intimately acquainted with the makers of the necessary plant.

BOOKS RECEIVED.

Honest Doubt, or the Price of Politics. By Sir Ernest J. P. Benn. London: Ernest Benn, Ltd., 154, Fleet-street, E.C. 4. Price 6s. net.

Reid's Handy Colliery Guide and Directory of Northumberland, Durham, Yorkshire, Cumberland, and Westmorland. Newcastle-upon-Tyne: Andrew Reid and Co., Ltd. Price 2s. 6d. net.

Adventures of an Obscure Victorian. By W. G. Riddell. London: Macmillan and Co., Ltd., St. Martin's-street, W.C. 2. Price 7s. 6d. net.

Berichtfolge des Kohlenstaubausschusses des Reichskohlenrates. Berlin: V.D.I. Verlag, Dorotheenstrasse 40, N.W. 7. Price 2·25 marks.

Obituary.

WILLIAM HENRY FOWLER.

BY the death of Mr. William Henry Fowler on the 4th inst., a familiar figure in Lancashire engineering circles has been removed. Mr. Fowler, who was seventy-eight years of age, had been in indifferent health for some time. He was a man with high scientific attainments, combined with a sound practical mechanical engineering knowledge. He received his earliest education at Oldham, and at the age of fourteen entered the foundry of Platt Bros. and Co., textile machinists, where his father was foreman moulder. After about two years in a similar occupation in another foundry, he spent a short time in the drawing-office, and while attending evening classes showed his ability by carrying off first-class honours and medal for machine construction and drawing, and similar awards for applied mechanics and steel manufacture. In 1872 he entered the service of the Manchester Steam Users Association as junior draughtsman, and in the following year gained a Whitworth Scholarship. He then pursued his studies at Owens College, now the Manchester University, and there he was awarded the Ashbury Engineering Scholarship and the Engineering Essay prize. After his college career he re-entered the service of the Manchester Steam Users Association as assistant to the chief engineer, and he continued in this post for about thirteen years, during which time he was engaged on work of different kinds concerned with the operation and construction of steam engines and boilers, the getting out of standard designs and specifications, making evaporative tests of engines, boilers and mechanical stokers. He studied and reported upon tests concerned with the injection of cold feed water on red-hot furnace crowns. He also investigated and reported upon boiler explosions.

This engagement was succeeded by one as works manager to the Chadderton Ironworks, and he subsequently practised as a consulting engineer in Manchester for several years. For a time he acted as editor of *The Practical Engineer*, and in 1898 founded the Scientific Publishing Company, Manchester. He was publisher and editor of *The Mechanical Engineer* until its suspension in 1917, and it was during this period that he read a paper before the Institution of Civil Engineers on "Boiler Explosions." His further activities included the publication of a number of text-books, including "Fowler's Mechanical Engineers' Pocket-book," "Fowler's Electrical Engineers' Pocket-book," and a text-book on the "Construction, Equipment and Working of Steam Boilers and Supplementary Appliances."

In 1906 he devoted his attention to the design and construction of circular calculating instruments to replace the ordinary straight slide rule, and shortly afterwards, in conjunction with his son, Harold, began to manufacture these useful appliances on a small scale. Subsequently, in 1920, after many years of painstaking research and experiments, a factory was established by Messrs. W. H. Fowler and Son, at Sale, Manchester, for their complete construction with microscopic precision. Illustrations and descriptions of these remarkable instruments have already appeared in THE ENGINEER. The latest device of the kind which has been produced is a pocket calculator specially designed for the use of architects, contractors, surveyors, and builders. With the aid of this instrument the user has all the advantages of the ordinary slide rule. In addition, not only can calculations be carried out freely in the decimal or duo-decimal notation, but quantities can be converted from one notation to the other by reading from the appropriate scale.

Mr. Fowler, in addition to being a Whitworth Scholar and a Past-president of the Whitworth Society, was a member of the Institutions of Civil and Mechanical Engineers and the Iron and Steel Institute.

ROBERT PILE DOXFORD.

IT is with regret that we have to record the death of Mr. Robert Pile Doxford, the third son of the late Mr. William Doxford, the founder of the firm of William Doxford and Sons, Ltd. Mr. Doxford, whose death took place at Eridge, Sussex, on March 25th, was in his eighty-first year. He began his training in 1867 by being indentured to Mr. J. F. Spencer, of the North-Eastern Marine Engineering Company, of Sunderland. After the completion of his shore experience, he went to sea for a period in order to gain the requisite and necessary knowledge for an all-round engineering training. Following his sea experience he was appointed to take charge of the general engine and brass foundry works of William Doxford and Sons, and 1877 he designed and built the Pallion engine and boiler works.

In 1886 his firm built a single-screw torpedo-boat, the "El Rayo," which was fitted with oil-burning locomotive boilers. This innovation, which was designed and carried out under the superintendence of Mr. Robert Doxford, created a new record at the time for this type of craft, the vessel attaining, on her trials, a speed of 21 knots.

As a director of the firm, Mr. Robert Doxford took an active and prominent part in the large extensions to the works that were made in 1904, by the addition of the West Yard and its new equipment of overhead gantries, while later he was responsible for the reconstruction, enlarging and refitting of the engine works which became necessary in order to deal with the large output of the opposed-piston marine oil engine associated with his name. He retired from active participation in the management of the firm some years ago, but to the last he retained his interest in a consultative capacity in the development of the Doxford oil engine.

Modern Double Helical Reduction Gearing.

ALTHOUGH improvements in materials and design have been contributory factors, the remarkable progress made during recent years in the efficiency, durability, and silent operation of the high-speed double helical gear has been largely due to the attainment of a higher degree of accuracy in gear cutting. In the early stages of development, the Metropolitan-Vickers Electrical Company appreciated that an entirely new conception of precision was necessary for this class of work, and the difficulty experienced in obtaining gears of the high standard demanded, particularly for turbine drives, led the company to lay down its own gear-cutting plant. At the same time research was begun with a view to achieving the highest attainable degree of accuracy in the cutting machines themselves, and to maintaining it by systematic checking and rectification. To this end the company has designed and manufactured special measuring devices capable of indicating errors in parts of the hobbing machines in units of one-ten-thousandth part of an inch. Similar apparatus has been made for measuring errors in the finished pinion or wheel in the same units, and it was with the aid of these devices that the company originated the method of showing on a developed plan the exact amount of tooth error in a helical gear at each axial and circular pitch.

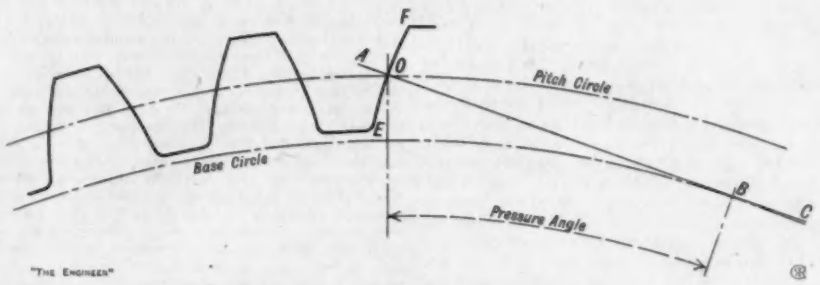


FIG. 1—DIAGRAM OF INVOLUTE TOOTH FORM

The importance of accuracy seems to be now generally accepted, and the modern reduction gear of the double helical type, far from constituting a weak link in a power transmission, is claimed to-day to be as reliable and durable as any other part of the system. Moreover, its efficiency is so high that its inclusion imposes an almost negligible loss on a power unit.

Tooth breakage at the roots in the case of high-speed gear of the type under review, is a contingency so remote as to be negligible, as the fixing of the correct tooth contact pressure automatically ensures a more than adequate root strength. Not a single case of tooth breakage, we are told, has occurred in the gears manufactured by the Metropolitan-Vickers Electrical Company, although during the past fourteen years more than 500 units with an aggregate horse-power of over half a million have been installed. The double helical type of reduction gear is now almost universally used for high-speed work, such as the drive of small and medium-capacity generators by turbines, and electric drives of various kinds. The advantages of the type are too well known to need expounding here, but they may be summarised as follows: —(*a*) Continuity of contact with distribution of the load over a number of teeth; (*b*) absence of end thrust; (*c*) smooth operation; (*d*) high efficiency.

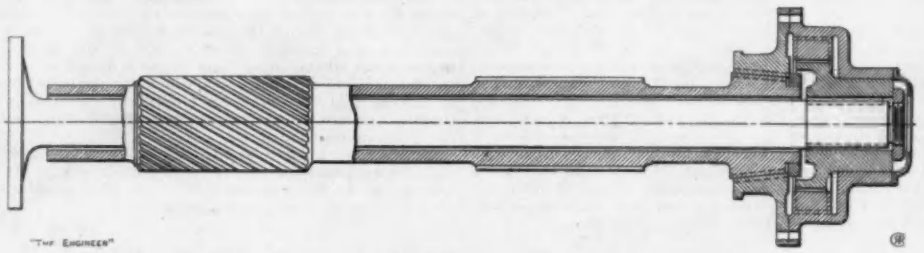


FIG. 2—FLEXIBLE PINION

For gears of this type the involute tooth form has now become general. It lends itself admirably to an easy system of automatic generation and has the advantage that one hob or cutter is suitable for a wide range of gears. The same hobs can be used for any gears of similar pitch and pressure angle, and being of few types they are more easily maintained at the necessary degree of precision, whilst the system in general lends itself to the attainment of the highest degree of accuracy in the finished gear. Moreover, with the involute form, a slight change in the distances between shafts does not destroy the uniformity of transmission velocity. The nature of an involute curve can be understood by reference to Fig. 1.

Two radii are drawn from the centre of the gear so that they form an angle equal to the required pressure angle. From the point O at the intersection of the one radius and the pitch circle the line A O C, known as the line of action, is drawn perpendicular to the other radial line, intersecting the latter at the point B, and forming a tangent to what is known as the base circle. The arc described with centre B and radius B O follows very closely the form of an involute tooth. The true involute E F, however, is formed by rolling the straight line O C upon the base circle so that the describing radius becomes less towards the base of the tooth and greater towards its tip. It will be seen that the true involute only coincides with the approximation at the point O.

Pinions may be either of the solid type, or, where conditions warrant it, of the quill drive type. In the latter case the pinion is made hollow and the drive is transmitted to the pinion by means of a flexible shaft, which passes through the pinion and is coupled to the end remote from the driving unit. Clearance is allowed between the pinion and the flexible shaft, and the arrangement permits of some change in alignment of the pinion and the coupling of the driving unit without throwing bending stresses on the pinion itself, and at the same time provides a degree of torsional flexibility. A part section of a flexible pinion is shown in Fig. 2.

Solid-type pinions are usually coupled to the driving unit by means of flexible couplings of the Bibby type, which provide a degree of flexibility together with some freedom of axial movement, thus allowing the pinion to adjust its lateral position to that of the gear wheel. Very rigid specifications are imposed on the material used for gears, and various modern methods are adopted for ensuring that such specifications are fully met. The pinion forgings for both types are made sufficiently long to permit the removal of a portion of the material from which test pieces are cut, and these are subjected to bending and tensile tests. After rough machining the forging is thoroughly annealed and tempered, uniformity of hardness being tested by the Brinell method. In addition to the above tests, the pinion is minutely examined during turning operations, and where the slightest defect is present the entire forging is subjected to microscopical examination and sulphur prints are taken.

The gear wheels are usually made of rims of forged carbon steel shrunk and pinned to cast iron centres, which, in turn, are pressed on and keyed to main shafts of high-grade forged steel. The same precautions and tests are applied as in the case of pinions, test pieces being cut from surplus metal on the side of the rim. The final turning of the face and sides of the rim is carried out after the rim, with its cast iron centre, is mounted on the main shaft, when, at the same time, the machining of the bearing journals is finished.

Gear-boxes are usually of cast iron, and reinforcing ribs are provided when necessary to ensure the utmost rigidity. Bearings for high-speed gears normally consist of cast iron shells lined with special white metal and arranged for forced lubrication, but in the case of double helical slow and medium-speed gears of smaller capacities roller bearings or ring-lubricated bearings are sometimes employed. Lubrication of the gear teeth is normally provided by one or more oil jets of elongated section, which direct oil under pressure into the entry of the meshing gears. In the case of turbine plant the main turbine oil pump is usually designed to provide the oil supply to the gear bearings and gear wheels.

The gear blank to be cut is mounted on a slowly rotating table driven by gearing, while the speed of the worm-shaped cutting hob is arranged with a definite ratio to that of the table. The hob starts the cut around the whole circumference of the blank as the latter rotates and slowly progresses down the face of the blank, the table speed slowly advancing relative to the hob speed in order to form the helix. In the case of smaller gears, the complete teeth are formed in one cut, while with the larger gears the cut is carried out in two stages. The first removes the major portion of the metal, after which the hob, which wears to some extent, is ground to accuracy and the finishing cut then taken. The cut across one of the helixes, which, in the case of a large gear may take as long as 170 hours, is always carried out in one continuous, uninterrupted operation. The process is similar in the case of pinions, but smaller machines, both of the horizontal and vertical type, are used. Fig. 3 shows a large hobbing machine with a completed gear wheel of 8ft. 6in. diameter for a mill drive. Fig. 4 shows a flashlight picture of a small pinion in the process of being cut in a vertical hobbing machine.

One of the devices which have been developed by the Metropolitan-Vickers Electrical Company for checking the finished product is known as the pinion measuring machine, already mentioned, and affords a means of measuring errors in a finished pinion in units of one-ten-thousandth part of an inch. In a machine of such accuracy of measurement, it is necessary that there should be absolute freedom from all avoidable constraints, and this has been satisfactorily achieved. The teeth of a helical pinion may be said to have two pitches, one axial and one circumferential, and both are measured by the machine in question. Means are provided to rotate the pinion by steps of the exact circumferential pitch, or by multiples of the pitch, and at each setting readings are taken along the pinion at the points of axial pitch to show the extent of the error in the tooth face at every point when referred to a selected datum. The actual measurement is made by means of a micro-indicator, the arm of which carries a spherical head, which is applied to the tooth face. This indicator is mounted on a cylindrical shaft resting in vees. The indicator is set at zero at the first point, and by the use of a series of gauges, differing in length by an amount exactly equal to the axial pitch, the fitting carrying the indicator is moved along the pinion and readings taken on the exactly corresponding point of each tooth.

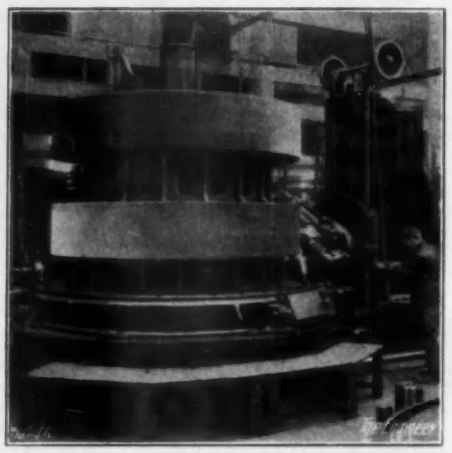


FIG. 3—HOBBING MACHINE AND GEAR

The pinion is then rotated by exactly the distance of the circumferential pitch in the following manner. A wheel mounted on the pinion under test has a flat groove turned in its rim in which rests a steel tape maintained under tension by means of weights as shown in Fig. 5. A horizontal portion of the tape leaving the wheel is arranged to lie parallel to a bar on which a shoe slides and which can be clamped to the tape at will. Resting against the end face of this shoe is the ball end of the lever of a second dial micrometer, which is carried on a second arbor running in guides. This micrometer is fixed to the arbor and is adjusted in position relative to the shoe by means of a micrometer head. Before rotating the pinion the arbor is adjusted to give a zero reading on the dial micrometer, and when set in this position a series of readings is taken along the axial pitch by the means described. The pinion is then rotated one circumferential pitch, which is measured by the insertion of a length gauge against the face of the shoe and adjustment is made until the micrometer reads zero. Further readings are then taken along the axial pitch, and by the employment of other length gauges the process is repeated for each circumferential pitch. As a result, a complete set of readings becomes available, showing the exact amount by which the teeth at the points in question are "high" or "low" when referred to the original datum point. These readings are set out on a developed plan of the pinion and show at a glance the variation in machining accuracy over the entire pinion, indicated in units of one-ten-thousandth part of 1in. The apparatus can also be employed for the measurement of the tooth profile, while a similar device is employed for the routine inspection of cutting hobs.

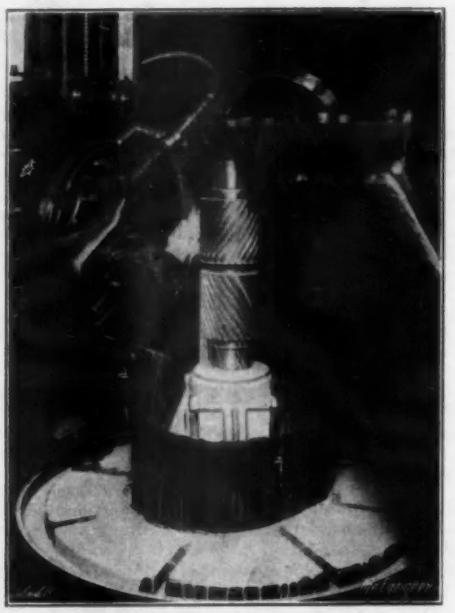


FIG. 4—SMALL PINION BEING CUT

The separate testing of gears for efficiency is not carried out on every set, because the range within which such efficiencies will fall is very small; the actual efficiency of gears of the double helical type as made by Metropolitan-Vickers may be said to lie between 98 and 99 per cent.,

SYDNEY HARBOUR BRIDGE—ARCH SPAN

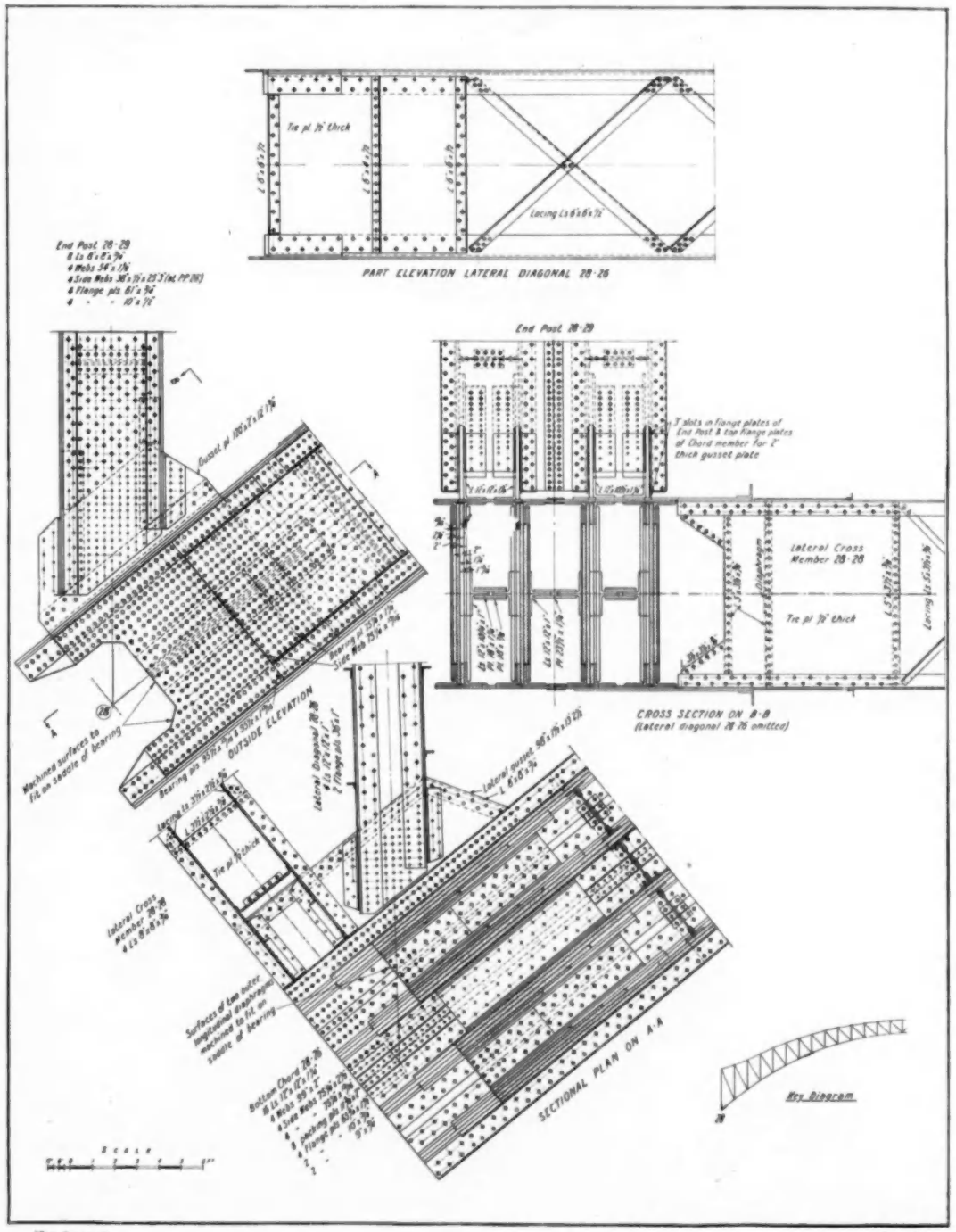


FIG. 14—CONNECTION 28

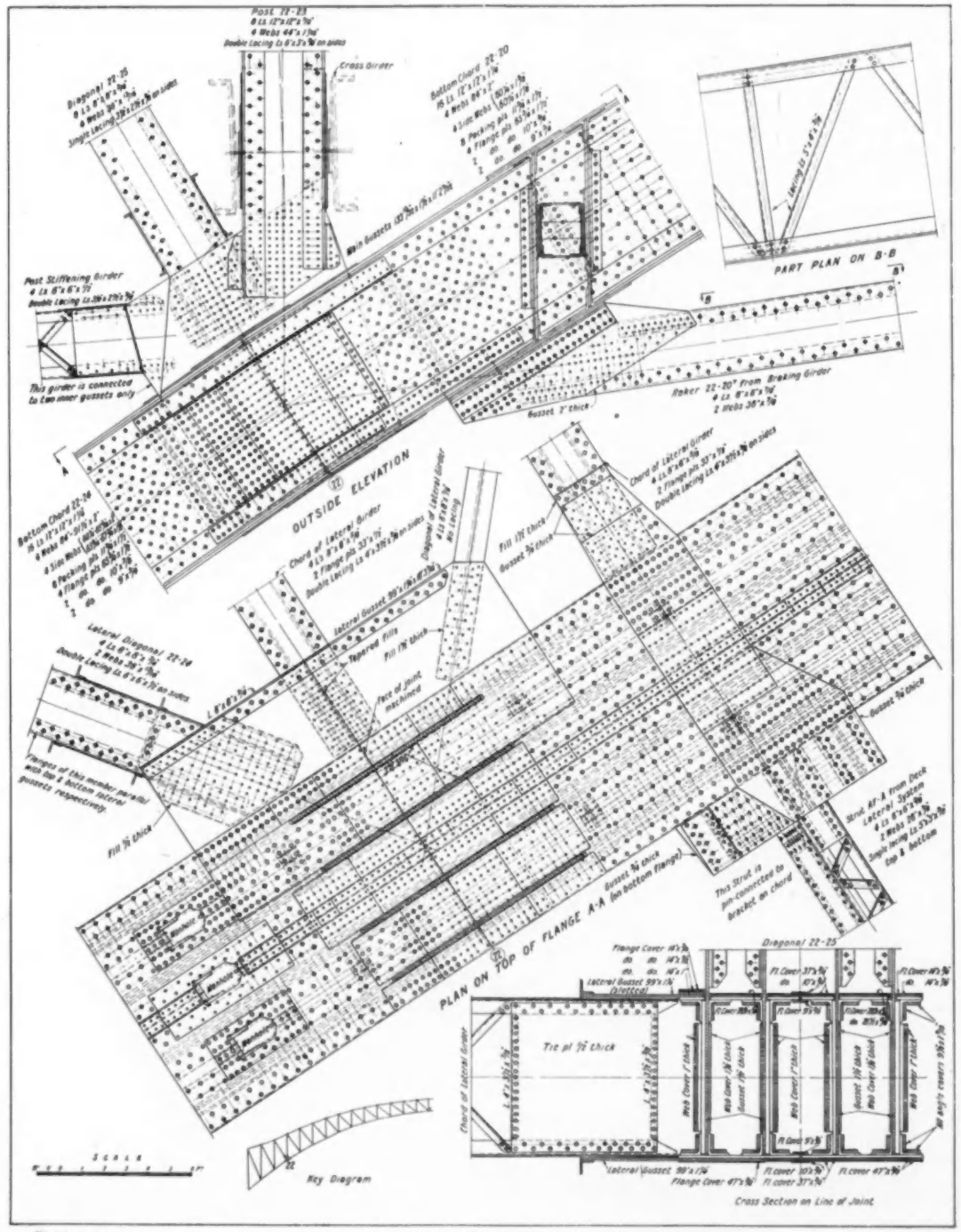
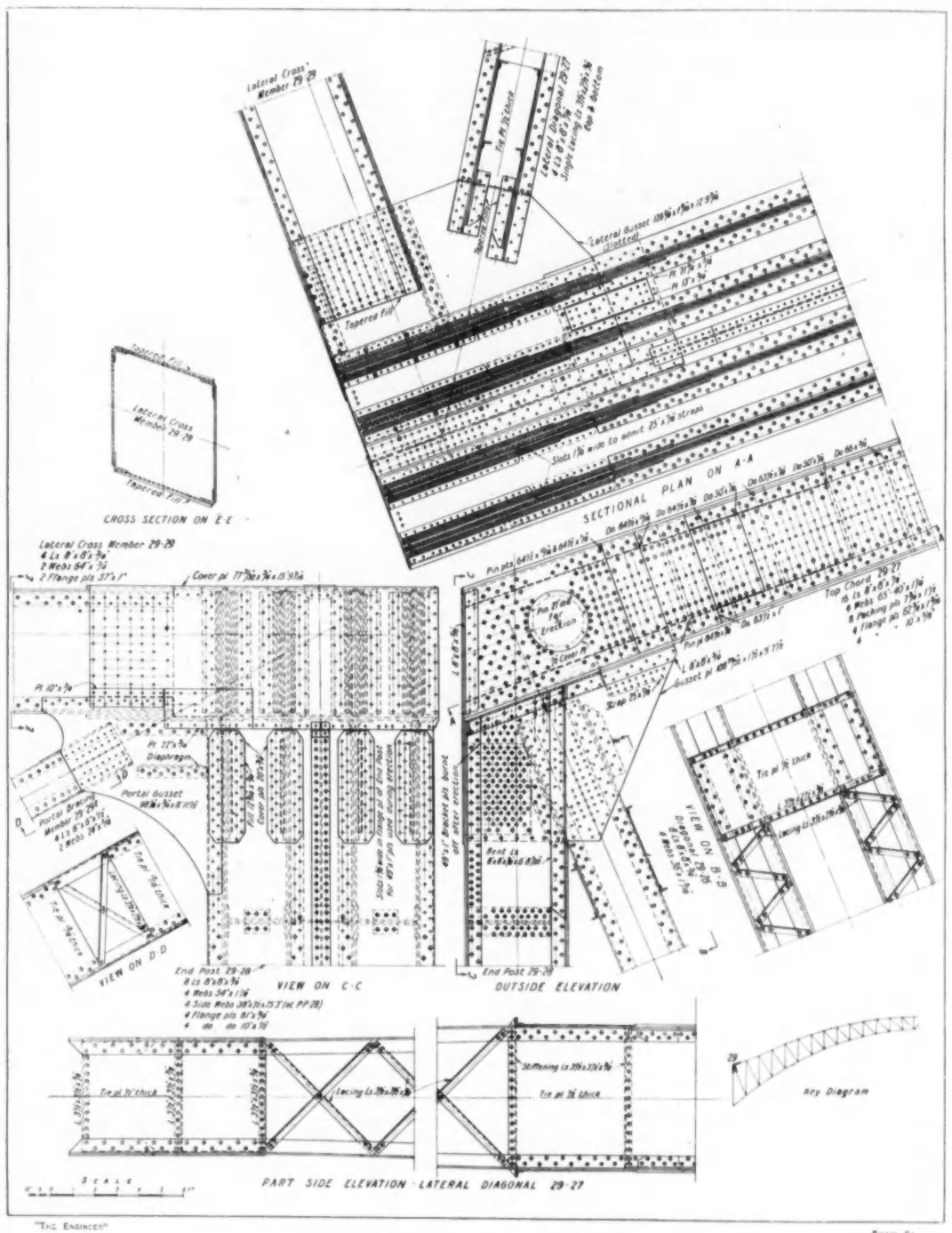


FIG. 15—CONNECTION 22

SYDNEY HARBOUR BRIDGE—ARCH SPAN

DORMAN, LONG AND CO., LTD., MIDDLESBROUGH, CONTRACTORS


Lateral Cross Member 29-29
Tapered Fill
CROSS SECTION ON E-E
SECTIONAL PLAN ON A-A
Lateral Gusset
Slots 7/8 wide to admit 25 x 3/4 straps
Lateral Cross Member 29-29
4 Ls. 8 x 8 x 3/4
2 Webs 64 x 3/4
2 Flange pls. 37 x 1"
Cover pl. 17 3/4 dia x 3/4 x 15 9/16
Pl. 10 x 3/4
Pl. 22 x 3/4 Diaphragm
Portal Gusset
Portal Bracing Member 29-29A
4 Ls. 6 x 6 x 7/16
2 Webs 38 1/16
Tie pl. 3/4 thick
VIEW ON D-D
Pin pls. 64 1/2 x 3/4 x 8 64 1/2 x 3/4
Pin 17" dia Erection
Cover pl.
Top Chord 29-27
4 Webs 65 x 40 x 1/16
6 Packing pls. 32 1/2 x 1/16
4 Flange pls. 65 x 3/4
Pl. 10 x 3/4
Bent Ls. 8 x 8 x 3/4 x 8' 10"
End Post 29-28
8 Ls. 8 x 8 x 3/4
4 Webs 54 x 1/16
4 Side Webs 38 1/16 x 15 3/4 (inc. PP 28)
4 Flange pls. 8 1/2 x 3/4
4 do do 10 1/2 x 1/2
VIEW ON C-C
OUTSIDE ELEVATION
Tie pl. 3/4 thick
Lacing Ls. 3 1/2 x 3 1/2 x 7/16
VIEW ON B-B
Stiffening Ls. 3 1/2 x 3 1/2 x 7/16
Key Diagram
SCALE
PART SIDE ELEVATION LATERAL DIAGONAL 29-27

"THE ENGINEER" BRAIN Sc

FIG. 16—CONNECTION 29 (PERMANENT)

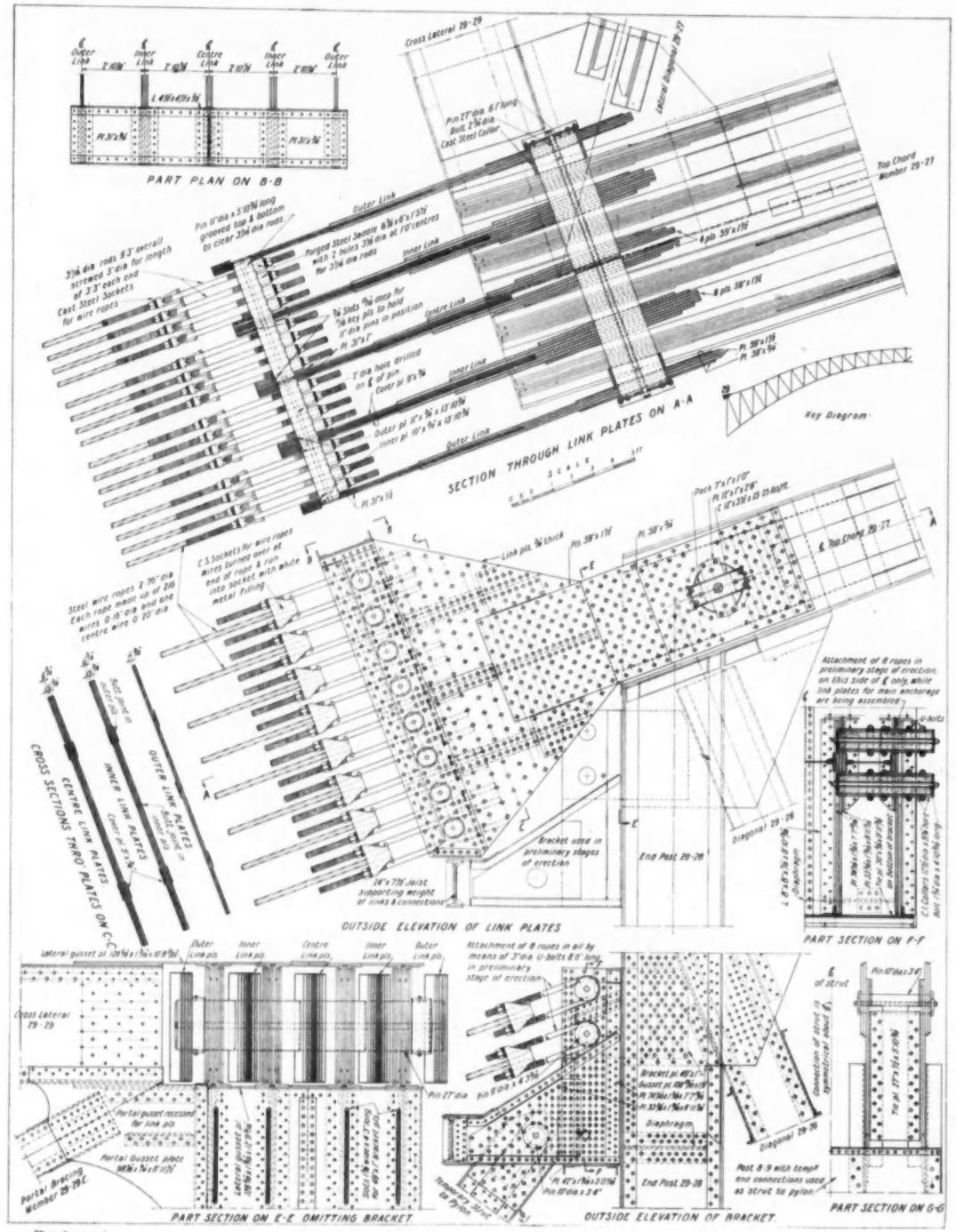

Outer Link
Inner Link
Centre Link
PART PLAN ON B-B
Cross Lateral 29-29
Pin 17" dia 6'1" long Bolt, 2 3/4 dia Cast Steel Collar
Top Chord Member 29-27
Pin 11" dia x 5'10 3/4 long grooved top & bottom to clear 3 3/4 dia rods
3 3/4 dia rods 9'3" overall screwed 3" dia for length of 2'3" each end for wire ropes
Cast Steel Sockets
Forged Steel Saddle 6 3/4 x 6 x 1'3 1/2" with 7 holes 3 3/4 dia at 7 1/2" centres for 3 3/4 dia rods
Inner Link
Tenon Link
3/4 Slots 1 3/4 deep for 7/8 key pls to hold 11" dia pins in position
1" dia hole drilled on ℄ of pin
Cover pl 17 3/4
Outer pl 11" x 3/4 x 13' 10 3/4
Inner pl 10" x 3/4 x 13' 10 3/4
Pl. 37 x 1/2
Pl. 38 x 1 1/16
Pl. 38 x 3/4
6 pin 38 x 1 1/16
Key Diagram
SECTION THROUGH LINK PLATES ON A-A
Steel wire ropes 2 3/16" dia Each rope made up of 216 wires 0.16" dia and one centre wire 0.20" dia
C.S. Sockets for wire ropes wires turned over at end of rope & run into socket with white metal filling
Link pls. 3/4 thick
Pcs. 38 x 1 1/16
Pcs 7 x 1 x 1'0"
Pl. 11" x 1" x 2'8"
C. 15" x 33 1/2 x 15 25 lbs/ft.
Top Chord 29-27
Attachment of 6 ropes in preliminary stage of erection, on this side of ℄ only, while link plates for main anchorage are being assembled
U-bolts
Bracket used in preliminary stages of erection
End Post 29-28
Diagonal 29-26
24" x 7" Joist supporting weight of links & connections
CROSS SECTIONS THRO PLATES ON C-C
CENTRE LINK PLATES
INNER LINK PLATES
OUTER LINK PLATES
OUTSIDE ELEVATION OF LINK PLATES
PART SECTION ON F-F
Lateral gusset pl 12 3/8" x 1 1/16" x 10' 8" bd
Outer Link pls.
Inner Link pls.
Centre Link pls.
Cross Lateral 29-29
Pin 27" dia
Portal gusset recessed for link pls
Portal Gusset plate 98 3/16" x 1 1/16"
Portal Bracing Member 29-29Z
Attachment of 8 ropes in all by means of 3" dia U-bolts 8'6" long in preliminary stage of erection
Bracket pl 48" x 1" Gusset pl 108 3/16" x 1 1/16" Pl 38 3/16" x 1 1/16" Pl 33 3/16" x 1 1/16"
Pl 47" x 1 1/16" x 5 3/16 Pin 17" dia x 24"
Diaphragm
Diagonal 29-26
End Post 29-28
Post 8-9 with temp'y end connections used as strut to pylon
℄ of Strut
Pin 17" dia x 34"
PART SECTION ON E-E OMITTING BRACKET
OUTSIDE ELEVATION OF BRACKET
PART SECTION ON G-G

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FIG. 17—CONNECTION 29 (ERECTION)

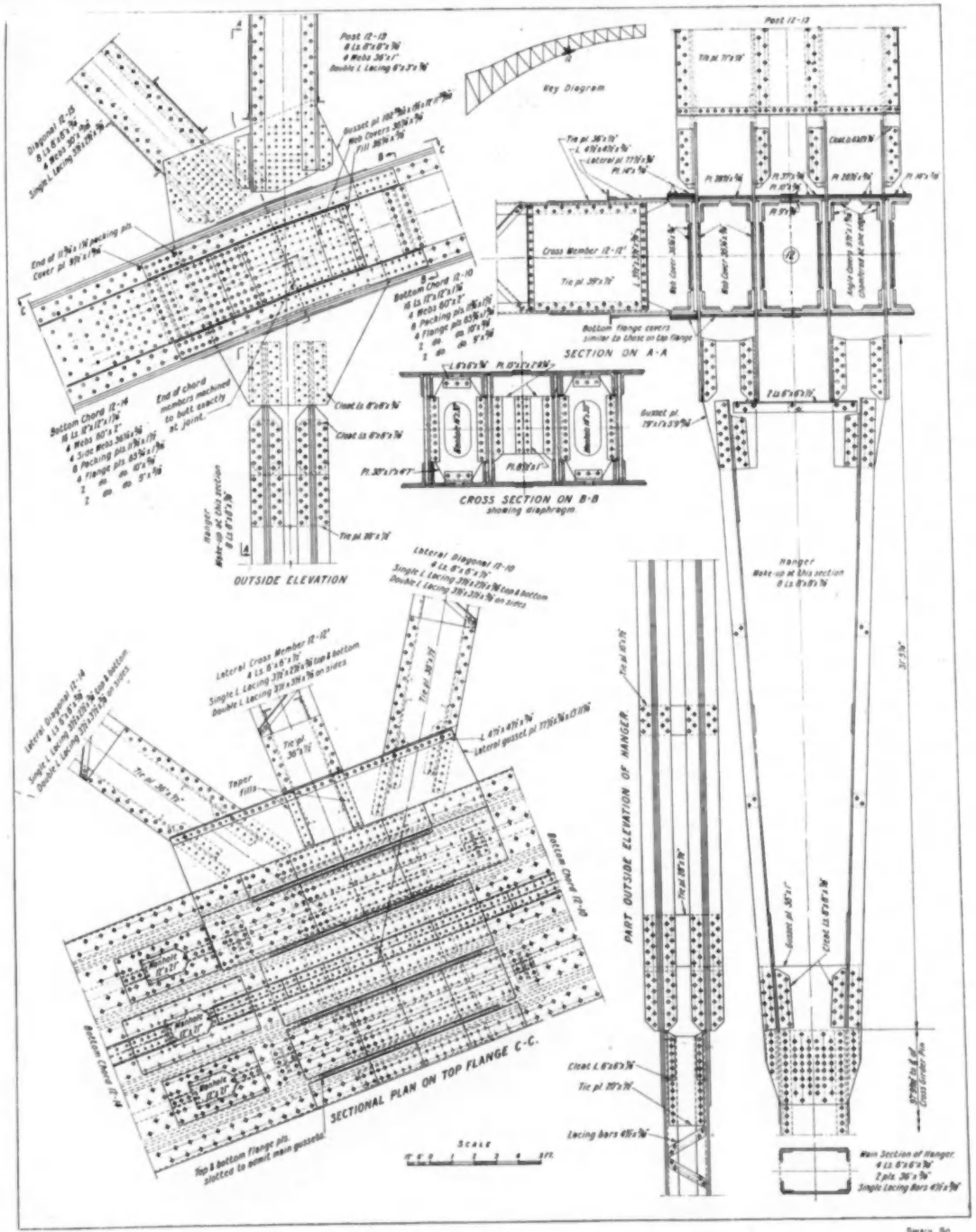

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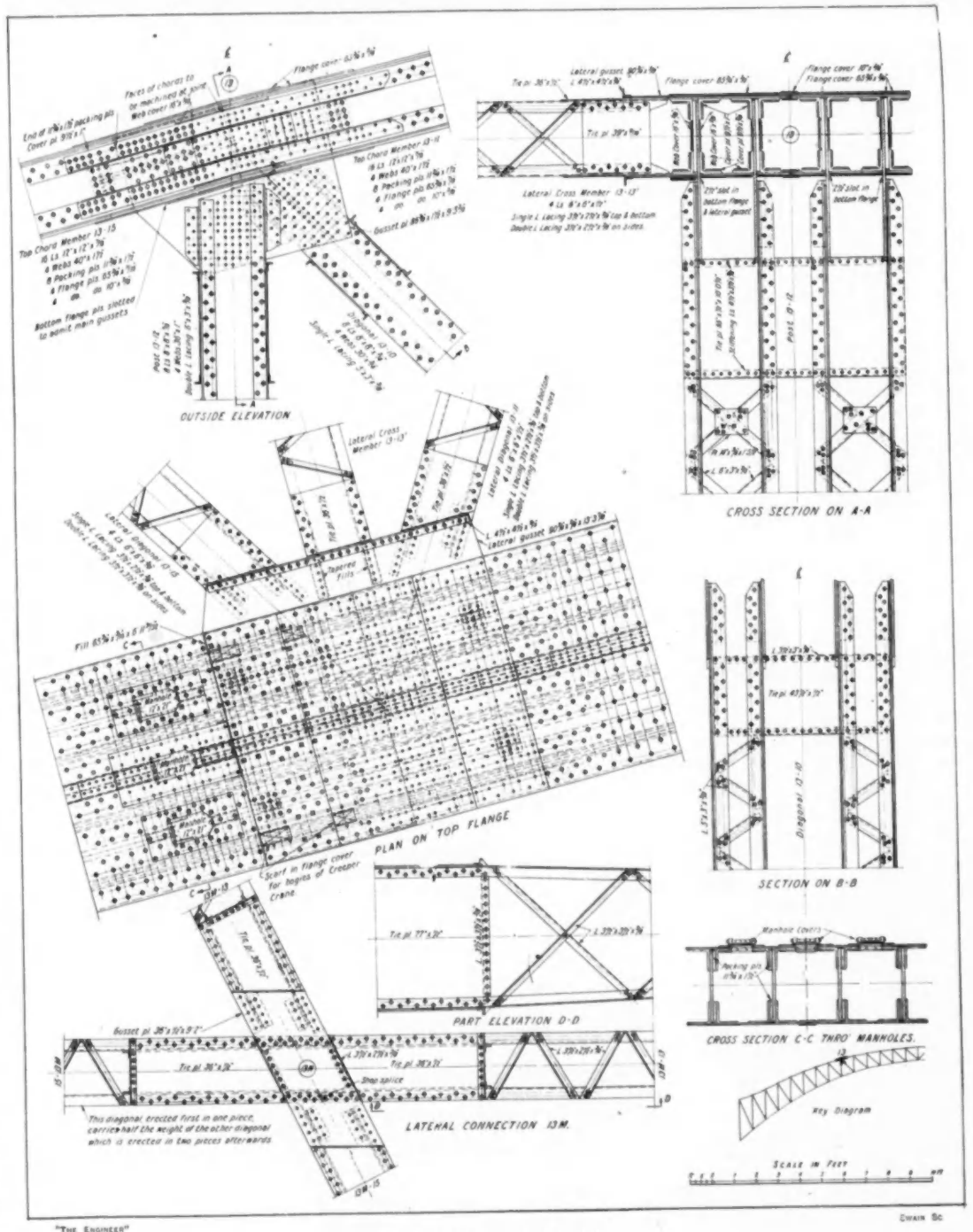
FIG. 18—CONNECTION 12



"THE ENGINEER"

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FIG. 19—CONNECTION 13

UNIV. OF MICH.

SYDNEY HARBOUR BRIDGE—ARCH SPAN

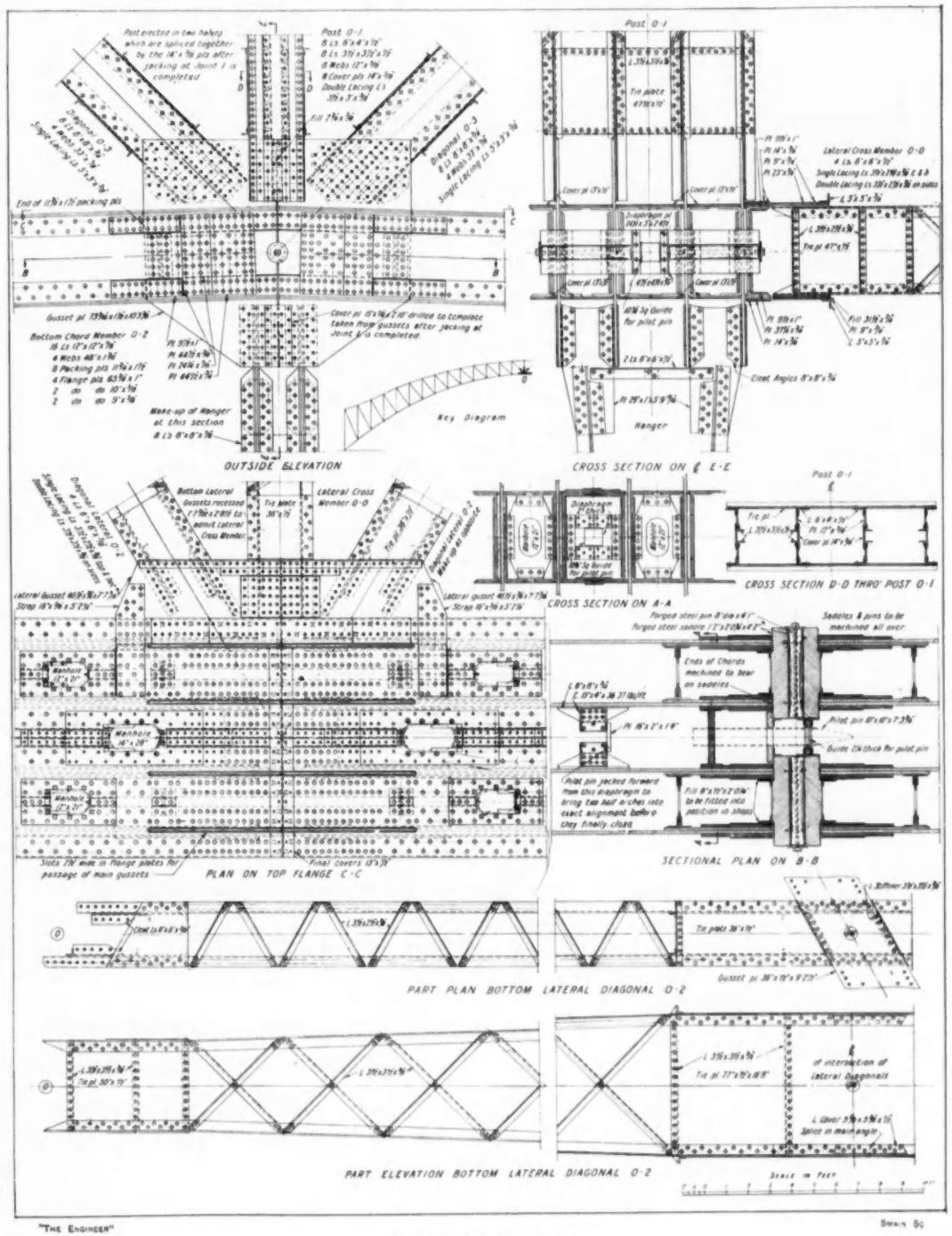


FIG. 20—CONNECTION 0

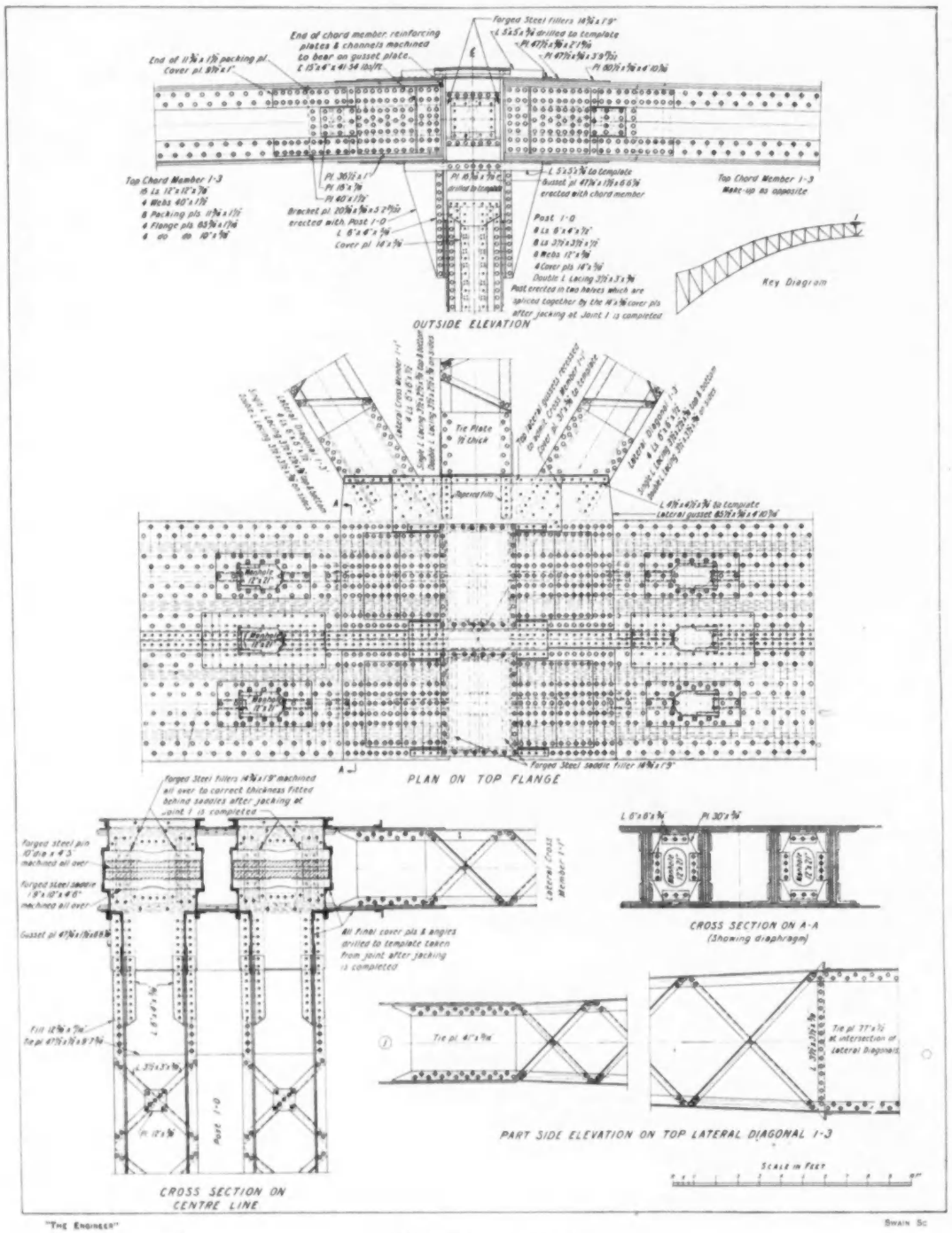

OUTSIDE ELEVATION
Key Diagram
Top Chord Member 1-3
Make-up as opposite
Post 1-0
Forged Steel Fillers
End of chord member reinforcing plates & channels machined to bear on gusset plate
Bracket pl.
Cover pl.
Gusset pl.
Post erected in two halves which are spliced together by the 14"x⅞" cover pls after jacking at Joint 1 is completed
PLAN ON TOP FLANGE
Tie Plate
Lateral Cross Member 1-1
Lateral Diagonal 1-3
Top Lateral Gussets recessed
Bottom Lateral Gussets recessed
Manhole
Forged Steel Saddle Filler
CROSS SECTION ON CENTRE LINE
Forged steel pin
Forged steel saddle
Forged Steel fillers 14⅞"x1⅞" machined all over to correct thickness fitted behind saddles after jacking at joint 1 is completed
All final cover pls & angles drilled to template taken from joint after jacking is completed
Fill
Tie pl.
Post 1-0
CROSS SECTION ON A-A
(Showing diaphragm)
PART SIDE ELEVATION ON TOP LATERAL DIAGONAL 1-3
Tie pl. 77"x½" at intersection of Lateral Diagonals
Scale in Feet
"THE ENGINEER"
SWAIN Sc

FIG. 21—CONNECTION 1

although even higher efficiencies have been shown on official tests. It will be apparent that the accurate measurement of efficiency in the case of gears is difficult unless special methods are employed to measure separately the actual losses, which are extremely small. A very

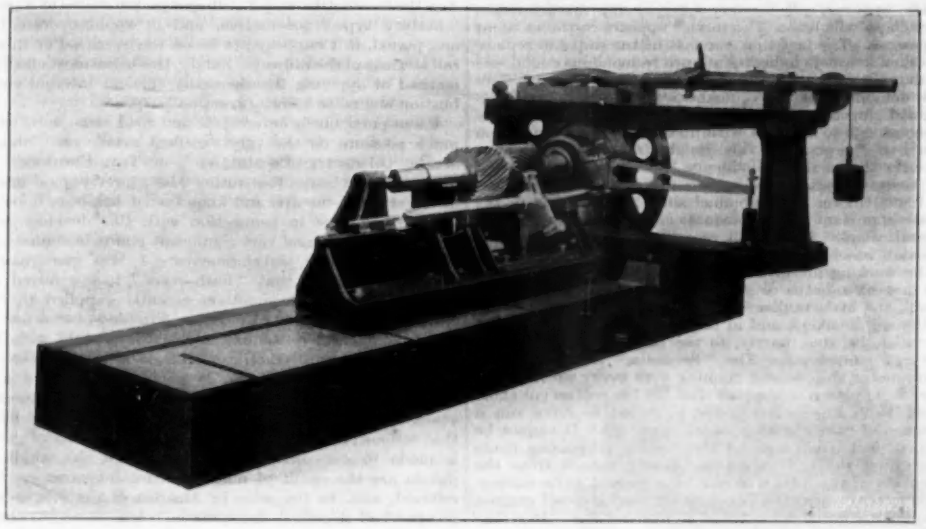


FIG. 5—PINION MEASURING MACHINE

complete series of tests was, however, recently carried out on a number of gears of various sizes, and the test results are interesting in view of the high efficiencies obtained. These gears, which are to be employed on the new Nile Delta land reclamation scheme, are of the

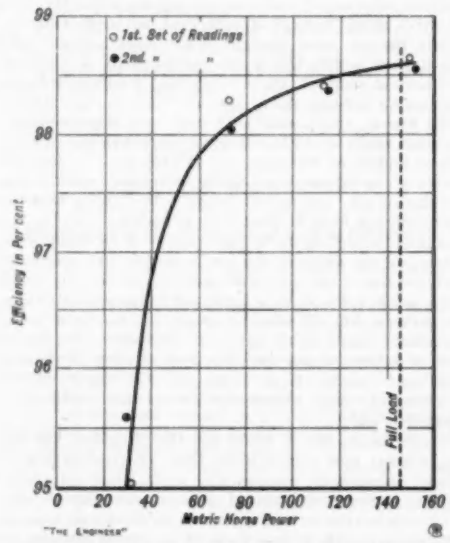


FIG. 6—EFFICIENCY CURVE FOR 14IN. GEARS

single-reduction type, and vary in power from 80 H.P to 430 H.P. They have an average speed ratio of 5 to 1, with centres of 14in., 20in. and 28in. respectively, and are employed for coupling motors running at 975 r.p.m. to low-lift pumps of the Gill type.

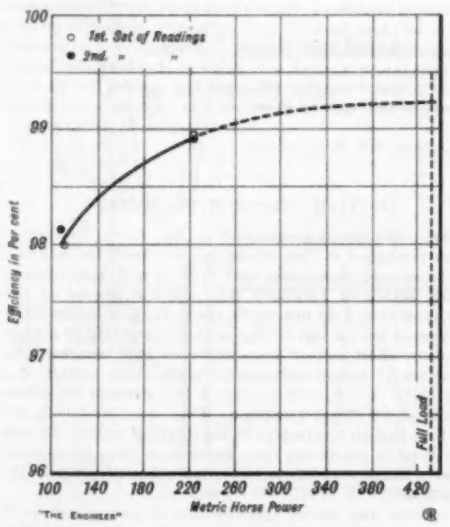


FIG. 7—EFFICIENCY CURVE FOR 28IN. GEARS

Roller bearings are fitted to both pinions and wheel shafts, and, owing to the inclination of the units at 45 deg., the gear wheels are provided with ball thrust races, which are fitted at their upper end. The gears are lubricated by a system of forced lubrication, each unit being fitted with a separate rotary pump driven from the lower end of the pinion. In the following tests the power absorbed by this pump is included.

A number of gears of each size were subjected to accurate efficiency tests under load. This was effected by the method of coupling together the low-speed couplings of a pair of similar gears and coupling the pinion of the one gear to an electric motor with the pinion of the other coupled to a generator. The motor and generator, which were existing test plate machines, were subjected beforehand to accurate tests for efficiency. For the test in question, the generator output was fed back to the motor, and accurate measurement made of the make-up power fed to the circuit to overcome electrical and gear losses, and thus a combined efficiency was obtained covering the motor and generator with the two sets of gears.

The efficiency of the motor and one gear was found by taking the square root of the combined efficiency, and from this result the efficiency of one gear is given by the ratio :

$$\frac{\text{Efficiency of one gear and motor}}{\text{Efficiency of motor.}}$$

Tests were taken on a number of gears of each size,

FIG. 8—GEAR WHEELS AFTER 10 YEARS' SERVICE

and the results of those of the 14in. and 28in. are shown in Figs. 6 and 7, representing the smallest and largest sizes. The result of one of the tests on the smaller size is shown in Fig. 6, and it will be seen that the efficiency was as high as 98·6 per cent. at the full load of 145 H.P. It was not possible to carry the load on the larger gears to the full rating owing to the limitations of the test motor and generator available at the time, but it may be noted that at a load of 225 H.P., or 52 per cent. of full load, the gears showed an efficiency of 98·93 per cent. The general characteristic curve of gear efficiency indicates that this gear at full load would have an efficiency of at least 99·2 per cent., and this probable extension to the curve is shown dotted in Fig. 7.

That the modern gear of the double helical type is as durable as any other part of a power system is said to have been amply corroborated by the performance of gears made by Metropolitan-Vickers Electrical Company in actual service. This cannot be better shown than in the case of reduction gearing for marine propulsion, a form of duty which is more arduous than land work owing to the relative lack of rigidity of the gear supports and to the stresses which result from ship motion. Some twenty vessels have been fitted with Metropolitan-Vickers reduction gearing for main propulsion of powers varying from 1750 S.H.P. to 6750 S.H.P., and after total journeys of about 5 million miles they have given no trouble of any description. Some of these gears have been in continuous service for over thirteen years, and are still in excellent condition.

The record for land work is said to be equally satisfactory. The first sets of gears made by the Metropolitan-Vickers Electrical Company for land work were put into commission in 1919, and these with all gears subsequently made by the company have shown an unbroken record of perfectly satisfactory operation. As a typical example of the durability of the modern high-class double helical gear, a picture is shown in Fig. 8 of the teeth of the pinion and wheel of a set put into commission in a Midlands colliery about ten years ago, which has been in commercial service ever since. This gear couples a turbine of 1000 kW, running at 3000 r.p.m., to a generator running at 600 r.p.m. It will be seen that the condition is excellent and the gears, which are mechanically almost perfect, are capable of an almost indefinite continuation of service.

The Progress of Motor Shipping.*

By A. C. HARDY.

INTRODUCTORY AND RETROSPECTIVE.

MOTOR shipping represents one of the most important and meteoric developments in the history of shipping, and the history of marine engineering must record that the "Vulcanus," a small tanker of 1911, and the "Selandia," a passenger and cargo ship of 1912, ushered in an entirely new era in sea transport. With these early ships and with the history of motor shipping we are not here concerned, except to point out that a power per cylinder which was considered good at just over 110 H.P. with twin screws in 1912, can in 1932 be regarded as something to be improved on at over 1100 H.P. on a single screw for similar ships. It is not also realised to the full that psychology plays a far greater part both in the choice and operation of machinery, and particularly of motor machinery, than the pure technician sometimes imagines. That is why some shipowners who "experimented" with motor ships in the early days of the internal combustion engine and made an unfortunate choice of type have been its most bitter antagonists ever since. Repair bills on the one hand, and chief engineers' tempers on the other, were not particularly calculated to persuade those in authority to repeat an experiment which, had a more fortunate type of oil engine been selected, would have proved so successful. That is why one motor ship among a fleet of steamers and with a steam-minded operating staff is seldom successful. That is why, in an all-motor ship fleet, the best results are obtained when the same type and make of engine is fitted throughout. A correct choice of *personnel* is also necessary for trouble-free operation.

MOTOR SHIPPING AS IT IS.

Although Great Britain approximately as at the end of 1931—and the position has not altered materially since—owns the greatest gross tonnage of motor shipping, Scandinavian countries collectively have the largest number. If, however, we analyse the total of 493 Scandinavian ships in service at that time, we find that Norway is by far the largest individual owner, as she has 311 vessels compared with ninety-eight for Sweden and eighty-four for Denmark. The great majority of these 311 vessels of Norwegian ownership, excluding 122 motor tankers under the Norwegian flag, are engaged in tramp work. This work is either of long-term or of short-term nature. The majority of it is long-term, a fact which has led to the suggestion that Norwegian motor tramps are not actually motor tramps at all, but motor liners.

As far as Sweden is concerned, a much greater proportion of the motor ship tonnage is engaged in liner work. Vessels like the "Gripsholm" and "Kungsholm," of the Swedish America Line, account for quite large bulks of tonnage of the total, whilst we must also remember the big cargo liner fleet of such companies as the Swedish East Asiatic Company. In Denmark the same applies. The East Asiatic Company maintains a large fleet of motor vessels running to the Far East, and, incidentally, still owns the "Selandia," which was the first ocean-going motor ship. Denmark also owns a big block of trans-North Sea motor ships of fast passenger-cargo and refrigerated type exemplified by the vessels of the United Steamship Company's Harwich-Parkeston route. Denmark is gradually turning over to internal combustion engine power the whole of the big fleet of inter-island ships operating from Copenhagen, upon the regular maintenance of whose services numbers of towns in Denmark are dependent for their transportation. It may be noted that none of the three Scandinavian countries has any native fuel, and that each can therefore maintain a perfectly open mind on the question of coal or oil. For either fuel, the price delivered at their bunkering stations is subject to a charge for transportation from the source. Great Britain's tonnage exceeds Scandinavia's tonnage, and this again is bulked up by such large ships as the "Britannic," "Reina Del Pacifico," "Aorangi," the large vessels of the Union Castle fleet and the Royal Mail fleets, of Elder Dempster and Co., and other liner companies. The motor tramp, as far as Great Britain is concerned, is numerically unimportant.

Germany had 161 motor ships in service—on the date of completion of these statistics—with a total gross tonnage of 547,116 tons. This figure is accounted for to a great extent by single-screw cargo motor liners of the Hamburg-American and Norddeutscher Lloyd companies, some of the most powerful German motor ships being the geared diesel liners "Milwaukee" and "St. Louis." These ships represent successful exponents of a type of diesel powering which might well be emulated in this country, and which may well prove to be the ultimate solution for the motor propulsion of passenger liners of very high power.

Holland has both a greater gross tonnage and a larger number of high-powered ships than Germany, the total figure being assisted by the large vessels in the Java trade of the Rotterdam-Lloyd and Nederland companies respectively. In Italy, although the total number is relatively small, the total tonnage is large. This applies also in the case of Japan, and is made up by the presence in the respective fleets of these countries of such ships as the "Saturnia" and "Vulcania," big Transatantic liners of nearly 24,000 tons gross each on the one hand, and on the other by the big Transpacific passenger liners of the Nippon Yusen Kaisha of nearly 17,000 tons each. In Spain the

* Institution of Naval Architects, March 18th, 1932. Abridged abstract.

gross tonnage is high in proportion to the number of ships in service. Much Spanish motor shipping, exclusive of tankers, is made up of small high-class coastwise tonnage, fruit-carrying ships and vessels trading to the Balearic Islands. It should be emphasised that nearly all Spain's motor ship tonnage is of modern, up-to-date type, some of it having been constructed in Italy.

Trends, Tendencies and Developments.

The motor ship has now been established sufficiently long as an instrument of maritime transport to make it possible to suggest definite trends and tendencies. It has established itself in a practically unassailable position for large cargo liners, for example, and development in size and speed in this class has been so rapid that in two companies we have seen the necessity for repowering mail liners under ten years old to obtain extra speed. Two years ago, or even less, it was in an equally strong position as far as passenger liners were concerned, but the developments of high-pressure steam, in conjunction with the cheap price at which boiler oil can be obtained in certain ports, has now rather altered the position here. The turbo-electric liner, too, in spite of higher first cost and very high fuel consumption, is also appealing, in some cases on grounds of passenger popularity and in other cases on grounds of the flexibility of load distribution which this type of propulsion permits, as an important rival to the motor passenger liner. If, however, we examine the attached performance figures of a large quadruple-screw motor passenger liner, completed in 1931, we shall still agree that both turbo-electric liners and high-pressure steam liners will have a great deal to do to better the motor ship's performance, and in any case the price of boiler and Diesel oil is something of which no one can foretell the future.

Voyage Performance of a Typical Motor Liner.

Displacement	21,694 tons	21,386 tons
Speed	18·73	18·06
R.p.m.	130·5	126·5
Fuel consumption, all purposes	58 tons	53·3 tons
$D^{2/3} \times S^3$		
Fuel/day	88,120	85,150
Approximate power, rated	18,000 S.H.P. at 135 r.p.m.	

Single and Multiple Screws.

The question of screws is one upon which attention has been focussed recently on account of the appearance of the quadruple-screw liners "Reina del Pacifico" and "Victoria" last year. The first big motor passenger and mail liner, "Aorangi," had four screws, largely owing to the impossibility of arranging the necessary power on two, and single-acting, two-cycle engines were used. After that the tendency was to concentrate high powers on twin screws, commencing with the "Gripsholm," of 1925, and going right through to the "Georgic," of 1932. Only in special cases were quadruple-screws fitted, as on the "Bermuda," where draught restrictions appear to have demanded it. The development of successful fast-running airless injection trunk engines and of improved single-acting, two-cycle machinery opened up a new vista for four-screw ships, especially when taken into consideration with the ever-increasing demands of passenger departments for more and more deck space.

Small Ships.

Below the 1600–2000 H.P. mark we have a slightly different set of conditions prevailing, but here, again, a delineation may be made and we can consider single-acting, two-cycle engines which must have airless injection and usually pump scavenge, and the four-cycle airless injection trunk monobloc unit. The crank case compression engine, like the hot-bulb unit, cannot hope much longer to have a marine appeal for a number of very obvious reasons. Yachts come into the group of motor shipping we are now discussing, and in normal times are a particularly lucrative outlet for manufacturers in this category. This is the school in which is being learnt so much about hull vibration and in which electric synchronisation provides a good solution.

Trawlers, drifters, small special passenger-carrying ships are all excellent cases for diesel engine application, and actually both two-cycle and four-cycle single-acting engines are each perfectly satisfactory for the work according to individual choice. When we consider cases below the 500 H.P. mark, we shall find that the field widens to embrace a group of small engines down to small "automative" units which can be mass-produced. Both two-cycle and four-cycle engines are used here, and it is in this category that diesel-electric propulsion for tugs has a big future. Except for ocean-going work, where a long-stroke engine permits of a slow-running propeller, the best results cannot be obtained with a direct-coupled, fast-running engine. Rapid manœuvring means a large starting air supply and is not beneficial to the cylinder liners. The advantages of bridge control in these floating shunting engines cannot be overlooked. The fact, too, that in certain types of ships such as ferries and passenger tenders a horizontal engine can be used to drive the generator is of value from a stability point of view. It secures also low headroom and is largely vibrationless.

Future Developments.

With the world-economic picture so confused as it is at the present moment, it is a little difficult to postulate specifically for the future. If, however, we may presume that return to normal which is an essential part and parcel of the future of shipping and shipbuilding, we might say that the future of the motor ship is a bright one. The Pacific and Indian oceans, in particular, offer great fields for expansion, and Japan has shown an example in this direction. Here, too, there is a considerable field for the diesel-engined tramp. The Pacific North-West Coast is an exporting region with large potentialities, not so much for manufactured goods as in grain, lumber, and fresh and tinned fruits. It is literally an ocean of all nations, and it can be said very truly that so far the Pacific Coast exporter has shown no signs of any particular flag discrimination. Motor shipbuilders will do well to study closely the designs of vessels already engaged in this trade with a view to going one better. A tendency of the past eighteen months or so on certain routes is to save the number of ships on a route by the substitution of one fast motor ship for two slow steamers. This was indicated in the case of the "Venus," operating between Bergen and Newcastle, and in the case of the "Victoria," running between Brindisi and Alexandria. Owing to the formation of a new Italian shipping combine, this latter vessel has now been transferred to the Bombay service which, however, calls for very different ship characteristics from those which the "Victoria" appears at the moment to possess. The fact that one fast motor ship can replace two slow steamers indicates at once tremendous confidence on the part of the owners in diesel engines for propulsion, and demonstrates the quickness with which a diesel-engined ship can be turned round at her terminal ports. It seems safe to say that with no other type of propulsion would this be possible. The Belgian State Railways have recently shown their confidence in this fact by ordering for their Ostend-Dover service the first fast, *i.e.*, over 21 knots, motor cross-Channel ship. This is one of the most important developments in motor shipping for several years. There still remains to be answered the question which has been asked for so long—What exactly is the working life of a motor vessel? It is only within the last six months or so that the first sea-going motor vessel, the little tanker "Vulcanus," built in 1911, went to the shipbreakers, and in this case the engine outlasted several hulls, due, partly, to the fact that the ship was carrying refined oils. The "Selandia," the first ocean-going motor ship, is still running with every success, and there is no reason to suppose that her life will be cut short owing to engine failure. She is stated to have run a distance of over a million miles in service. It cannot be said, in fact, that some of the gloomy prophecies made concerning the life of marine diesel engines from the inception of this prime mover have proved to be correct. The matter of successfully operating marine diesel engines is largely a psychological and a personal one. It rather looks as though in the future a great deal more attention is going to be directed towards this side. Meantime, we may repeat that although tonnage production figures for the world are exceedingly low, those for motor shipping appear to be holding their proportionate position quite well.

Letters to the Editor.

(We do not hold ourselves responsible for the opinions of our correspondents.)

OIL-ELECTRIC LOCOMOTIVES.

SIR,—There has been quite a lot of very interesting and valuable discussion taking place during the last few months in THE ENGINEER concerning the present position of the so-called "oil-electric," or, as some people, for some unfathomable reason, call it, the "Diesel-electric," railway locomotive. May I suggest, Sir, that it is high time we began to call it by its proper name, so that we can get back to earth once more? In making that remark I am bearing in mind the kindly remarks made concerning my first "thermo-electric" locomotive investigation which I made now thirty years ago—in 1902—by my friend, Mr. John W. Hobson, M.I. Mech. E., in a very enlightening paper which he read in 1925, before the Institution of Engineers and Shipbuilders at Newcastle-on-Tyne. This early "Durtnall" thermo-electric locomotive was designed for harbour shunting duties at the time of the Boer War.

The fundamental principles embodied in this first so-called "oil-electric"—or what I term a thermo-electric—locomotive, is to-day to be seen in what I believe is the most successful thermo-electric locomotive in the world, namely, locomotive "No. 1525," on the New York Central Railway. The locomotive is a double-bogie type fitted with four traction motors, which in the aggregate, can produce 1580 horse-power on the one-hour rating. The oil engine used is a 300 B.H.P. fitted with six cylinders, 10in. by 12in., which engine always runs at its normal speed of approximately 550 r.p.m., and naturally—when operating under such ideal conditions—gives the lowest fuel consumption, as it is always at "full-load," either supplying current to the traction motors, or to the 218 cell storage battery carried on the locomotive, which is of a capacity of 680 ampère-hours on the six-hour rating. The cost must have been pretty high, as I notice that there were no less than four well-known firms each contributing to its construction, namely, the American Locomotive Company, the Electric Storage Battery Company, the General Electric Company, and the Ingersoll-Rand Company, and I believe the locomotive is doing first-class service on shunting duties in the West Side yards of New York, where smoke is very objectionable, as would be the case if normal steam shunting locomotives had been used. The locomotive is also able to collect current from the overhead, or third-rail, sections over which it may pass.

I think, Sir, if I may do so, it would be a good thing here to draw notice to a matter which should now receive more serious attention, in connection with all "thermo-electric" locomotives. It is, that we should now give up, as quite misleading, the rating of the locomotives according to the brake-horse-power of the oil engines. To the ordinary steam locomotive man it is very puzzling, used, as he rightly is, to the rating of steam locomotives in accordance with the tractive effort produced. I respectfully submit that we should rate the locomotives in some more simple manner, such as, for instance, on the "one-hour rating" of the traction motors. As an instance of what I mean, I may say that the above-mentioned American thermo-electric locomotive weighs in working order 114 English tons—about 161 lb. per rated traction motor horse-power; it would be hardly correct to rate this excellent locomotive in accordance with its engine power, namely, a 300 horse-power locomotive. It would be obviously wrong to do so, as the traction motors produce as much as 1580 horse-power on the "one-hour rating," and as it is the traction motors which really haul the trains it surely is correct to term it a 1580 horse-power locomotive.

It is, of course, a very reliable locomotive, as, even if one took out the oil engine, its fuel tanks, radiators, &c., the locomotive would still operate for a time as a pure "battery type" locomotive, and it would operate for any period, if it happened to be on the overhead or third-rail sections of the railway. Surely, this is the most efficient method of applying the thermally efficient internal combustion engine to railway traction purposes.

I was particularly interested, and read same with very much pleasure, in the very excellent article on "Status of the Oil-electric Locomotive" in THE ENGINEER of January 29th last. The author has a pretty good grasp of the state of the art, and knows what has been done in various countries in connection with this development. He referred to several very significant points in connection with the present developments. I was particularly struck on learning that "flash-overs" had occurred on the "oil-electric" locomotives recently supplied to the North-Western Railway in India. Flashing-over is one of the troubles which we had a deal of trouble with on some of my earliest traction work. It is always liable to occur unless special types of generators, motors and control gear are employed. During the last twenty years, however, we have never had any trouble from that serious cause of breakdown, as all our electrical plant is made to our own special design, and the windings put in are the result of much practical experience. He referred, also, to the price in America of the 300 horse-power "oil-electric" locomotive being some £12,000, which figure seems outrageously high, because if he is referring to the horse-power of the engine, this means that on the motor rating the price per horse-power is £50, assuming that the motor rating was as high as 240 horse-power.

He also refers to the famous "Baldwin" two-stroke locomotive. I have often wondered why such a departure from good steam locomotive practice was made in this shunting locomotive, and that having six axles, they did not drive them, instead of only four, as is the case, or, if four motors were thought quite good enough, why they did not couple the wheels mechanically in the well-tried normal manner. By so doing they would have better adhesion for utilising the meagre 550 horse-power obtained at the wheels, which must have been very disappointing; but what really could be otherwise expected from twelve 9¾in. cylinders at 450 r.p.m.? It only goes to indicate how very careful one has to be in locomotive work not to take the cylinder rating "too high." It is a pity that the engine did not have at least 11in. cylinders. As it is, the combination making up the locomotive is far from satisfactory, as the writer of the article states that only some 750 horse-power has been obtained from the engine, which drives a 750 kW, or 1070 horse-power, generator, whilst the, perhaps, 500 kW which is generated, has to be really inefficiently used, in no less than four 250 horse-power traction motors, which can only work at about little over "half-load" each. Even under the best conditions the otherwise excellent locomotive cannot be expected to do efficient duty.

In conclusion, Sir, I would say that England was the first to break new ground along these progressive lines of railway locomotive engineering, and, which is pretty evident, is more appreciated in countries abroad than in our own territory; but, of course, our locomotive manufacturers have only to look forward to foreign markets for their products, with the exception of the relatively small industrial home locomotive trade. It does seem strange that preference is given to worn-out fallacious ideas in place of those which are the result of experience.

Interesting as it is, and always has been to me, the present types of thermo-electric locomotives do not, I am convinced, represent the future policy. I am more and more convinced that a much more rapid development will take place, as soon as it is thought proper to proceed along well-tried and reliable "steam" engine practice. All that is now wanted, is to improve the thermal efficiency of the "heat" engine. Research has pointed the direction in which this can be done, so why not get on with the job?

WILLIAM P. DURTNALL.

London, S.E. 5, April 5th.

BRITISH LOCOMOTIVE DESIGN.

SIR,—The opening remarks in Mr. P. C. Dewhurst's letter published in THE ENGINEER for April 1st, have led me to re-read the section on "Valves and Valve Gear" in my article of February 5th. Careful perusal of this will show that I do not credit the G.W.R. with the introduction of piston valves, but with the building of a high-pressure, short cut-off locomotive so long ago as 1902. Long travel piston valves were adopted to permit of a true early cut-off, and to give a free exhaust by virtue of the short steam passages. Thus was produced, not the first British locomotive to have piston valves—though that type of valve was then uncommon—but an embodiment of locomotive efficiency comparable with present-day standards.

To trace the actual introduction of piston valves in British locomotive practice, it is necessary to go back beyond even Mr. W. M. Smith, for a batch of 4–4–0 locomotives built for the North-Eastern Railway in 1874 had valves of this type, and I am not certain that even these were the actual pioneers.

Although the Midland Railway employed piston valves extensively from the beginning of the century, they cannot be said to have come into general use on the

railways of this country until the adoption of superheating commenced in about 1910.

Mr. Dewhurst's remarks on the proportioning of grate area will find ready acceptance; but, on the other hand, it seems quite conceivable that a low exhaust pressure may fail to create an adequate velocity of air through the fuel bed on a large grate, and thus, with some varieties of coal at least, may introduce combustion difficulties. This is what appears to militate against very short cut-off working on the Gresley "Pacifics," although the G.W. "Kings," with considerably smaller grates, but only slightly less cylinder volume, seem to find no trouble.

There is but little difference between the haulage capabilities of these two classes, certainly nothing like the 20 per cent. superiority in grate area possessed by the "Pacific," and this again lays open to question the advantage of the wide fire-box in these days of early cut-off working.

W. A. TUPLIN.

Huddersfield, April 2nd.

INSTITUTION DISCUSSIONS.

SIR,—Your leader on "Institution Discussions" and the letter from "R.P." raise a question which must be causing concern to the councils of all technical institutions, and the solution is not easy to find. I cannot help thinking that the success or otherwise of a discussion depends not on whether it is stage-managed or not, but on:

(1) The "discussability" of the paper itself.

(2) The general interest of the paper being such as to compel members to read their advance copy and come prepared to take part, and

(3) The methods adopted by the chairman.

The advance copies of the paper render it quite unnecessary for the author to read more than a summary, so leaving time for a good discussion, and this appears to be borne out by the fact that the average number of speakers for the last ten London meetings of the Institution of which I have the honour to be secretary has been thirteen, and the average time occupied by each seven minutes.

It will be generally agreed that the adjournment of the discussion has been tried and found wanting, and that the proper time for allowing "anyone both to study the paper at leisure and also to think over the best way of bringing home any point he wished to make" is *before* the reading of the paper and not after.

BASIL H. JOY,
Secretary, I.A.E.

London, W.C. 2, April 5th.

Resistance Vacuum Furnace.

By A. J. MADDOCK, M.Sc., A. Inst. P., AND H. CHENEY, B.Sc. (Eng.).

THE resistance furnace to be described has been constructed for the heating under vacuum of small metal parts for the purpose of degassing them. Consideration of the type of work for which it was to be used led to the following conclusions:—

(*a*) The furnace must be horizontal.

(*b*) Loading and unloading of the boats containing the metal parts under treatment should be speedy and not involve elaborate vacuum seals.

(*c*) The winding should be easily accessible for renewal if necessary.

(*d*) A wide range of temperatures should be available up to a maximum of 1400 deg. Cent.

Bearing these points in mind, the furnace was made, practically throughout, of mild steel. A single flat plate closes it after loading, the joint being rendered vacuum tight by a rubber gasket. The winding is situated within the evacuated space, thus doing away with the necessity of keeping it in a reducing atmosphere for the higher temperatures. The complete winding and tube in which the boats are placed can be removed as one unit for renewal of the wire when necessary or for the insertion of a different winding for a different range of temperature, this being advisable to avoid excessive loss of power in external resistances if used on D.C.

The construction can be gathered from Figs. 1 and 2, the latter showing the various parts with the furnace unassembled. The outer tube A, Fig. 1, is of weldless steel, 4in. bore and ¼in. thick. It is closed at one end by a steel blank F, the junction being arc welded. This is the method adopted for all the permanent joints, the number of which has been reduced to a minimum, namely, three, and if care is taken in the welding, satisfactory vacuum-tight joints result. To the front end of A is welded the flange C, which carries six protruding bolts for clamping down the cover plate D, of ⅜in. mild steel, for closing the furnace during exhaustion. The soft rubber gasket R, ¼in. wide by ⅛in. thick, makes a vacuum-tight seal; a small V-groove in the flange and cover plate serving to prevent R being squeezed out of place when the nuts are screwed home. This seal is the only one of a temporary nature in the apparatus.

The furnace winding W is wound directly on an alundum tube B, 2in. bore, with ¼in. walls, and it is into this tube that the boats are loaded. For some purposes a mild steel tube may be used, in which case the winding is insulated from it by several layers of asbestos paper. The tube B is supported concentrically within A by the flanges G at each end, which are a tight fit on B up to shoulders ground on the end of this latter, but an easy fit within tube A; a third flange at the centre prevents sagging of the tube. These flanges have seven holes drilled through them to reduce loss of heat by conduction, and to provide free access to the space around B for exhaustion. They have also a portion cut away by a secant for a depth of ⅛in. sufficient to clear the exhaust tube E, which projects within the tube A by ¼in. The portions cut away allow the furnace tube to be inserted past E, and then, when pushed up against F, turned through a small angle, so that the projection of E forms a stop to prevent the tube being moved when boats are withdrawn from it. Ample clearance of ¼in. is allowed between E and G for expansion of B when the temperature is raised.

In order that there shall be only one vacuum joint of rubber, the main body of the furnace and the cover plate constitute the two terminals of the winding, the rubber gasket forming the insulation between them. One end of the winding is connected to the metal stop S—which is provided to prevent the boats being inserted beyond the end of the winding—and thence to the furnace body by a short lead to a screw in the inner flange G, while the other end terminates in an iron strap around the alundum tube. On this strap is the screw X from which a flexible lead of iron—*e.g.*, a Bowden cable or similar material—insulated by porcelain beads, is taken to the terminal M on the inside of the cover plate. A corresponding terminal N on the outside forms the attachment for the incoming cable. Both M and N are screwed into blind holes in D, thus obviating the necessity for any further vacuum-tight joints. The flexible lead is long enough to permit the cover plate to be withdrawn from the bolts in C and the lead removed from or attached to the terminal M easily. To insulate the clamping bolts, which project from C and pass through D, large clearance holes are drilled in the latter and a ring K of grey fibre is affixed to it by screws with heads recessed ¼in. This fibre ring has holes of only just sufficient diameter to permit the easy passage of the clamping bolts, thus locating the cover plate D without any possibility of the bolts touching the metal. To equalise the pressure on the fibre when the nuts are screwed home, a steel ring L, ¼in. thick, is attached to the fibre by small screws which project into it by only ⅛in.

It is thus seen that with this design no extra insulating and vacuum-tight seals are necessary for leading the current to the winding, the "earthed" main is connected to the screw P, rendering the whole of the main furnace housing at earth potential; whilst the "live" main is connected to N. A cover, attachable to C by three bayonet catch fittings and visible in Fig. 2, provides protection from the "live" cover plate when the furnace is in operation.

A cooling jacket H, through which water continually circulates by the inlet and outlet tubes W_1 and W_2, prevents heat conduction along the tube A outwards, and thus keeps the rubber gasket cool. To reduce heat losses a square section sheet iron box, filled with magnesia plastic, surrounds the remainder of A, which latter is supported by two cross pieces inside. The lagging material is never disturbed once the furnace is set up, as the outer tube A is always left in position. It is the tube B complete with the winding that is removed for changing the temperature range or renewal of the wire.

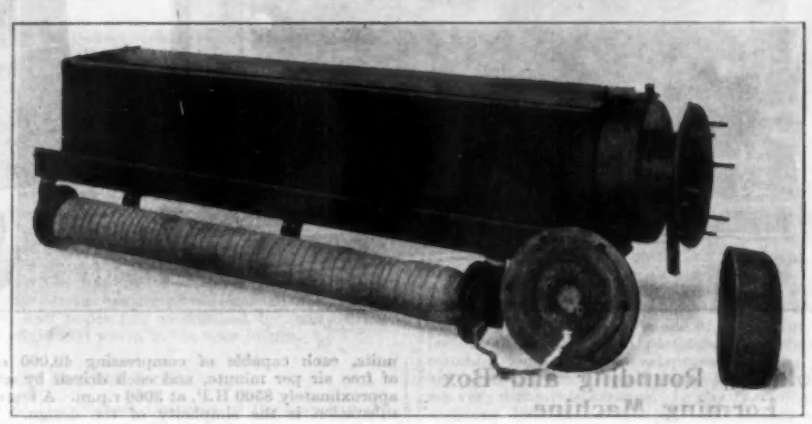


FIG. 2—PARTS OF RESISTANCE VACUUM FURNACE

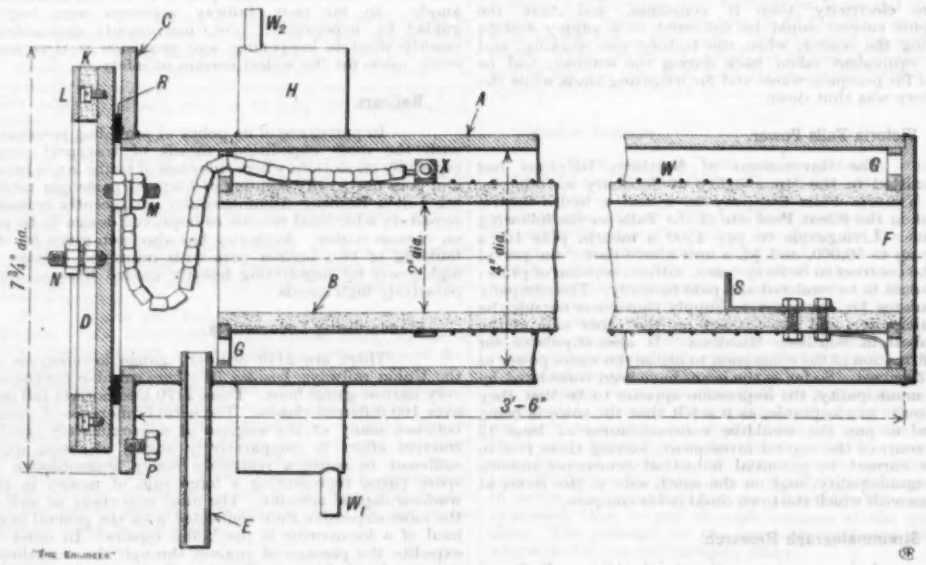


FIG. 1—SECTION THROUGH RESISTANCE VACUUM FURNACE

The furnace can be used either on A.C. or D.C., provided one side of the supply is earthed. If, however, D.C. is used, several inner tubes should be constructed with appropriate windings for different temperature ranges in order to avoid excessive power loss in resistances for the lower temperatures. We have, however, used one winding for all temperatures up to 1400 deg. Cent. and a tapped transformer on an A.C. supply for temperature regulation. For this we have used a winding of molybdenum wire, 0·04in. diameter, wound 3 t.p.i. The winding extends from S towards the front for a distance of 34in. with a gap in the centre to clear the support ring, the wire being passed through a portion cut away in the ring. It may be stated that the furnace as described has been in almost daily use for about six months, at 900 deg. Cent., taking 1750 watts, and giving every satisfaction.

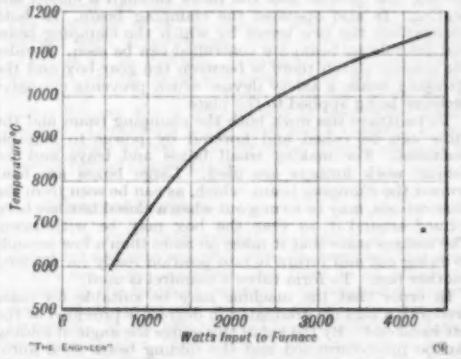


FIG. 3—CALIBRATION CURVE

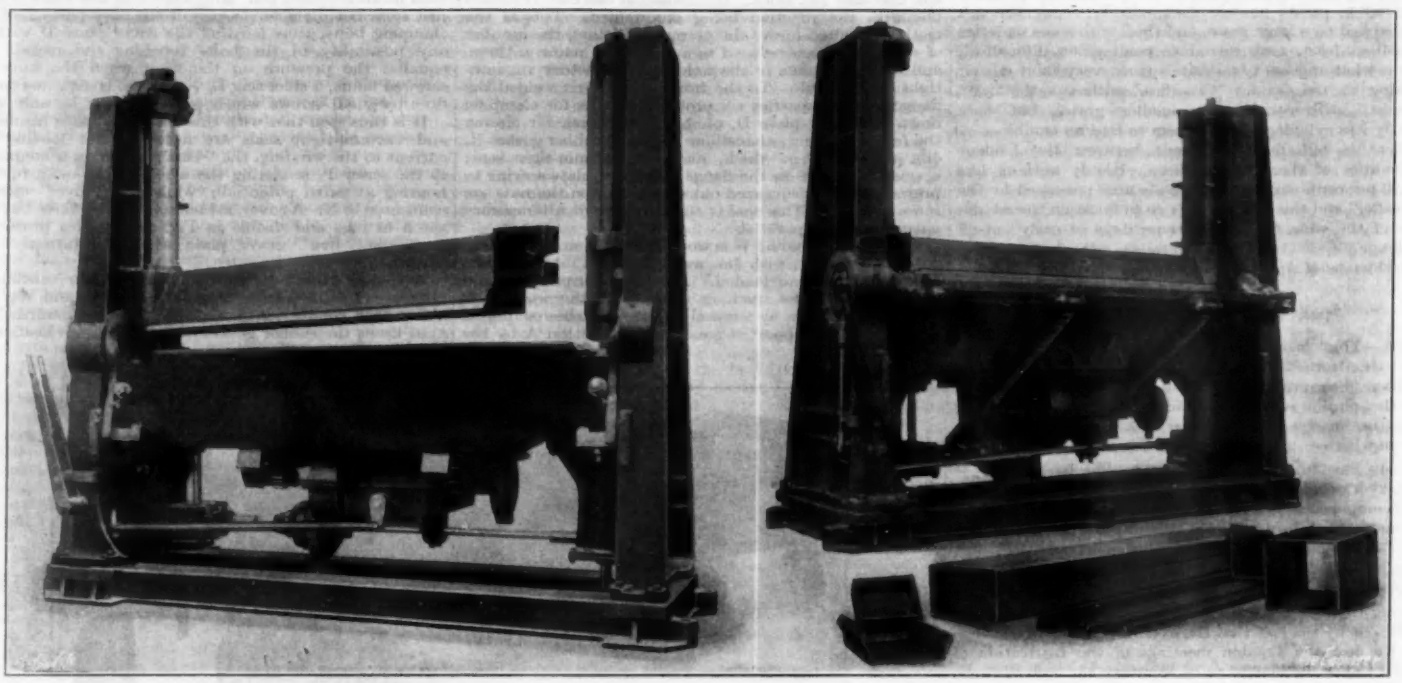
For obtaining the temperature within the furnace, a cover plate—visible in Fig. 2—with a thick plate glass window in the centre, clamped between rubber gaskets, is used so that an optical pyrometer can be sighted on a plug of asbestos in the centre of the furnace tube. The temperature for various values of watts input to the furnace is noted and a calibration curve prepared—see Fig. 3, which was obtained with a molybdenum winding, as described. Once this has been done, the plain cover plate can be used in regular furnacing work, the temperature being known from the watts input, or, more simply, from the current drawn from the mains.

With a rotary oil pump whose limiting pressure is 5 microns of mercury, the pressure attainable with the furnace cold is 10 microns and under working conditions at 900 deg. Cent. a steady value of 15 microns seems to be obtained. With a better, more rapid-acting pump, and shorter connecting tubing, it is to be expected that a lower pressure could be obtained, if it were necessary.

The authors desire to express their thanks to the British Thomson-Houston Company, Ltd., in whose laboratories this work was carried out, for permission to publish this description.

A FOLDING, ROUNDING AND BOX FORMING MACHINE

JAMES BENNIE AND SONS, LTD., GLASGOW, ENGINEERS



A Folding, Rounding and Box Forming Machine.

THE machine illustrated by two engravings on this page has been designed by its makers, James Bennie and Sons, Ltd., of Govan, Glasgow, to facilitate the flanging and bending of steel plates prior to electric welding. The makers claim that it is of particular utility in the manufacture of switchgear cases, transformers, wagons, safes, and tanks, &c. Some examples of the work the machine is capable of performing are to be seen in one of the engravings. Folding and bending into many shapes can be performed, and boxes, closed on four sides, both with and without flanged ends, can be made.

At the rear of the machine there is a table upon which the plate to be folded rests. It is securely clamped to the table by means of the clamping beam. The actual flanging is performed by the folding beam at the front of the machine. In the left-hand illustration this beam is shown in the lowered position, while in the other it is partly raised. From the two illustrations it will be seen that the folding beam is carried by swivelling arms which have trunnions rotating in the main standards. The rotation is effected by means of two racks, driven by pinions, which exert a pressure upon the outer edge of the beam.

The machine is operated by a continuously running electric motor mounted at the rear of the table and driving the pinions and the racks through a clutch and gearing. It also operates the clamping beam. In both illustrations the two levers by which the clamping beam and the folding beam are controlled can be seen. Besides the control clutch there is between the gear-box and the clamping beam a safety device which prevents excessive pressure being applied to the plate.

To facilitate the work both the clamping beam and the table can be raised and lowered by power to suitable positions. For making small boxes and trays and for similar work formers are used. Large boxes are bent around the clamping beam, which, as can be seen from the illustrations, may be swung out when a closed box has been formed around it, so that the box may be withdrawn. The makers state that it takes no more than a few seconds to swing out and return it into position ready for forming another box. To form tubes a mandrel is used.

In order that the machine may be suitable for mass production a gauge graduated in degrees is provided at the left-hand end. By the aid of this gauge the angle of folding can be pre-determined and the folding beam then automatically bends the plate to the required degree each time. Machines of this type are made in various sizes to deal with plates from 6ft. by $\frac{1}{4}$in. up to 12ft. by $\frac{1}{2}$in.

South African Engineering Notes.

Vereeniging Extensions.

THE power station, belonging to the Victoria Falls and Transvaal Power Company, at Vereeniging, is being extended by the addition of two 32,500 kW generator sets and four boilers, each of a nominal rating of 160,000 lb. of steam per hour. The first 32,500 kW set, at present being installed, will be a straight addition to the plant, but the second 32,500 kW set will replace an existing A.E.G. 10,000 kW machine in the south-east end of the building, and will represent an increase of capacity of only 22,500. These sets are identical with the one which has been in service for about a year. The boiler-house is being extended to accommodate the four new boilers, which are of the latest Babcock and Wilcox design and embody several noteworthy features. One of the new compressor units is now nearing completion at the substation. The present programme comprises two units, each capable of compressing 40,000 cubic feet of free air per minute, and each driven by a motor of approximately 8500 H.P. at 3060 r.p.m. A feature of this substation is the simplicity of the design. With the development of the Far East Rand the demand for power is growing constantly, and part of the company's extensions now in progress is the erection of two separate 80,000-volt transmission lines from Vereeniging to Vlakfontein, about 5 miles due south of Springs. At Vlakfontein a distribution station is being built from which the power from Vereeniging will be reticulated. Two 20,000 kW synchronous condensers are to be installed at this distribution station, and the supply of wattless current will enable the voltage to be maintained in the event of one line having to carry the whole load while the other line is out of service. A 20,000 kVA synchronous condenser is on order for the Robinson power compressor station. The total cost of the extensions now in progress is not far short of £1,000,000. It is interesting to note that the aggregate capacity of the turbine plant connected to the company's system when the extensions are completed will be 420,000 kW, while the steam capacity will be about 377,000 kW.

Electricity for Natal Sugar Mills.

A scheme for generating electricity at Natal sugar factories has been submitted to the Durban Town Council by Mr. John Roberts, the Borough Electrical Engineer, who holds that, if given effect to, the scheme would not only bring about economical working in the factories themselves, but also, by utilising current for irrigating lands, would greatly increase the production of cane. He adds that a sugar factory equipped with a suitable electric generating plant could generate much more electricity than it consumes, and that the surplus current could be delivered to a supply station during the winter, when the factory was working, and the equivalent taken back during the summer, and be used for pumping water and for irrigating lands while the factory was shut down.

Victoria Falls Power.

The Government of Northern Rhodesia has submitted to the Municipality of Salisbury an offer by the Victoria Falls Company to install a hydro-electric plant in the Silent Pool site of the Falls on the following terms:—Livingstone to pay £500 a month, plus 1d. a unit up to 50,000, and $\frac{1}{2}$d. a unit above that; the period of the contract to be forty years, without revision of price; accounts to be rendered and paid monthly. The company stipulates for the right to supply consumers outside the municipality, and also others on the other side of the Zambesi in Southern Rhodesia. It also stipulates for confirmation of the concession to utilise the water power of the Zambesi. So far as the terms have been considered by the municipality, the impression appears to be that they are quite unacceptable, as it is felt that the town is being asked to pay the would-be concessionaires at least 12 per cent. of the capital investment, leaving them free to offer current to potential industrial consumers outside the municipality, and on the south side of the river, at prices with which the town could never compete.

Stremmatograph Research.

A few years ago the South African Railways Administration acquired a set of stremmatographs, and extensive investigations have been undertaken ever since. As many as sixteen stremmatographs are very carefully clamped to the bottom flange of the two running rails, and when everything is ready a test locomotive is allowed to run backwards and forwards at speeds varying from dead slow to the maximum. The stresses under the loads are recorded on petrol smoked circular glass discs, and accurately read by means of a microscope having a magnification of 75 and reading to one eight-thousandth of an inch. One of the first investigations was the determination of the stresses in the main line under various main line locomotives, when it was proved that the track was amply strong, and a recommendation made that the average axle load could with absolute safety be increased. On one occasion it was questioned whether locomotives with axle loads of 14½ long tons (2240 lb.) could be permitted to run on well-sleepered, well-ballasted 60 lb. branch lines, where 13½ tons was formerly considered to be the maximum. The stremmatograph test that followed showed conclusively that no danger whatever would be incurred by allowing the increase. This conclusion was of very great value to the Administration. There are many locomotives with axle loads ranging from 13½ to 14½ tons which were, until then, confined to main lines, where they were not as efficient haulers as the more powerful 18-ton axle load engines. Now in the event of the Administration needing branch line engines it can draw on this group, which can, in turn, be replaced by up-to-date main line engines. Suggestions were made to increase the number of sleepers on the main line by one per 40ft. rail, and from the maintenance point of view the idea was excellent. Stremmatographic investigations, however, proved that under existing conditions no improvement to the track was necessary, as there is very little likelihood of the average axle loads of locomotives being much increased for many years to come. The huge expenditure that would be incurred by the introduction of an additional sleeper per rail length was not warranted. A stremmatograph investigation of great interest to locomotive engineers was one which proved that an engine, with all its driving wheels flanged, could be run round sharp curves provided (*a*) the fixed wheel set could negotiate the curve apart from the leading bogie and trailer, and (*b*) the amount of side play for the two latter was ample. In the past, railway engineers were largely guided by experience; now, instruments demonstrate exactly what is happening, and provision is thus more easily made for the widest margin of safety.

Railcars.

In pursuance of its policy of providing passengers with the most expeditious means of transport, more especially on sections where this class of traffic is not heavy and does not justify running of frequent passenger trains, the Union Railway Administration has recently commissioned six additional railcars of improved design to be put on various routes. Authority has also been given for the building of two further cars with improved engines of high power for negotiating heavily graded lines at comparatively high speeds.

Standardising Locomotives.

There are 2170 ordinary gauge locomotives on the Union railways, besides 70 others suitable for certain very narrow-gauge lines. These 2170 locomotives fall into over 100 different classes. The actual difference of design between many of the engines of approximately similar tractive effort is comparatively slight, although quite sufficient to cause a relatively heavy accumulation of spare parts, representing a large sum of money in the working capital account. The most important, as well as the most expensive item connected with the general overhaul of a locomotive is the boiler repairs. In order to expedite the passage of engines through the workshops, it is usual to hold in stock and ready for use spare boilers of different classes, which are exchanged for boilers removed from engines undergoing heavy repairs. The boilers replaced are repaired in sequence of urgency, and are then included in the spare boiler stock. But the system of boiler exchange is only economically practicable when there are sufficient engines of any particular class to warrant the purchase of at least one spare boiler for that class. For the 2100 standard gauge locomotives on the S.A.R., there are in stock 197 boilers, in thirty-five different classes, of an approximate value of £290,000. Even this large number does not provide spare boilers for classes

and sub-classes consisting of only two or three engines each. Accordingly, the Chief Mechanical Engineer has been conducting exhaustive investigations with a view to introducing boilers of standard types, suitable for use in more than one class of locomotive, at the same time standardising, as far as possible, the numerous boiler fittings and spare parts which must be kept in stock for repairs to the boilers themselves, and by incorporating up-to-date features and design, improving the haulage capacity of the engines to which the standardised boilers could be fitted. By making certain alterations to the frames, &c., of the locomotives, the Chief Mechanical Engineer has designed two standard type boilers which can be used for thirteen classes, comprising forty-seven engines. The cost of alterations to the engines will be only about £320 each. Investigations will be continued, and it is, no doubt, only a question of time until the range of use of standardised boilers is considerably extended to include other classes of engines now fitted with boilers of different designs.

Rhodesia–Walvis Bay Railway.

The report of Mr. W. Jeffaries, who conducted the railway reconnaissance survey of the proposed Rhodesia–Walvis Bay Railway, indicates that the construction of a railway from Walvis Bay to Rhodesia would be comparatively easy. Mr. Jeffaries recommends that if the line be built it should follow the general route of Gobabis to Matetsi, *viâ* Landfontein, Eersterust, the Botletle River. The average mileage would be 549, and the average cost £4010 per mile. The total cost would be £2,381,698. The amount of steel required for all purposes would be 123,100 tons. Mr. Varvill, the Chief Engineer of the Rhodesia Railway, in his report, considers that a relatively cheap line could be built in three years. He also suggests that before the final decision is taken the alternative route from Matetsi to link up at Grootfontein in South-West Africa, should be investigated. This route could skirt north of the Mabebe depression and cross the Okevango Delta at its upstream end.

World Power Conference in Scandinavia.

THE Swedish National Committee of the World Power Conference, acting in agreement with the National Committees of Denmark, Finland, and Norway, announces that a sectional meeting of the World Power Conference will be held in Scandinavia from June 26th to July 10th, 1933. The technical sessions will take place in Stockholm.

All countries represented in the organisation of the World Power Conference are invited to take part in the 1933 sectional meeting, to offer through their National Committee reports for publication, and to appoint official delegates.

The programme is to be concentrated on the energy problems of large-scale industry and of transport.

Attention will primarily be devoted to fundamental engineering and economic problems rather than to questions of technical detail.

PROGRAMME OF DISCUSSION.

General.—Energy supply: power and heat; special energy problems of certain branches of industry; electrical heating; transmission and adaptation of motive power for industrial machinery.

Transport.—Railways; marine transport.

Power and Heat.—Among the many subjects in this vast field, attention should be focussed upon the question of how large industrial plants can meet their energy requirements in the most economical way. A main point will be to investigate whether it is better for a large industry to have its own power stations or to purchase power from the general electric supply or, eventually, how to combine both systems.

A main theme running all through this section will be the economic importance of the load factor, applied both to the power supply and to the industrial plant as a whole.

Steam Heat Consuming Industries.—This section is primarily intended for special energy questions of the pulp and paper industries, such as cooking, drying and ventilation.

The Iron and Steel Industry.—In this group combinations of metallurgical processes and power production by steam and gas motors, distance transmission of gas *versus* local gas production, methods for increasing the energy economy of furnaces for heating and melting will be covered.

Electrical Heating.—This section of the programme embraces the utilisation of electrical heat for melting, heating, and other heat treatment of ferrous and non-ferrous metals.

Motive Power for Industrial Machinery.—The introduction of the individual electric motor drive, the use of synchronous motors, speed regulating devices, gears, &c., will be discussed in this section.

Railways.—The competition between electrification and the use of steam and Diesel locomotives for long-distance traffic, and the competition between electric railway and omnibus transport for city and suburban needs will be amongst the subjects dealt with.

Marine Transport.—Motor *versus* steam propulsion, electric power transmission, will be discussed with regard to the various requirements entailed both by fast traffic and by cheap freight traffic.

FIGURES just compiled show that last year Durban established a new electricity record by selling over 100 million units. Durban is now believed to sell the cheapest current in the world, and the figures show it is much cheaper than in any other part of South Africa. Johannesburgh and Cape Town lag far behind in the use of electrical cooking appliances and refrigerators, and the latest statistics show the wisdom of Durban's extensive attempts to popularise electricity.

Provincial Letters.

THE MIDLANDS AND STAFFORDSHIRE.

(From our own Correspondent.)

Substantial Work for Midlands.

WORK of considerable dimensions has recently come to the Midlands, and a number of firms will be much busier in the near future as a result. Indeed, it is probable that one firm's works will be fully occupied for a year or more. News was received in Birmingham at the beginning of the week that Stewarts and Lloyds, Ltd., the Birmingham and Glasgow firm of manufacturers, had secured a large part of the contract for a pipe line, 1300 miles long, to carry oil through Irak, Palestine and Syria to the ports of Haifa, Tripoli and Basra. Tenders provided for 150,000 tons of steel piping, valued at more than £1,000,000. In addition, tenders had been invited for the work of laying the line, estimated to cost another £1,000,000. In the rolling stock industry the Birmingham Railway Carriage and Wagon Company, Ltd., of Smethwick, has received from the L. and N.E. Railway Company an order for 220 steel containers, each of 4 tons carrying capacity. Morris Commercial Cars, Ltd., of Soho, Birmingham, are to supply twenty-two vehicles to Holland, sixteen to India, twenty to the Irish Free State, four to Shanghai, six to Java, and various lorries to Cairo, St. Lucia, Rhode Island and Denmark. Braithwaite and Co. (Engineers), Ltd., of London and West Bromwch, have secured some good contracts for steel work, much of which will be fabricated at the works in this district. They have the contract for the replacement by a steel structure of an existing timber bridge on the railway at Peterborough, the steel work for which approximates 650 tons. The firm is to supply some 250 tons of heavy plate girders and stanchions for bridge work at Chesterfield. It is to erect a screw pile jetty, consisting of five dolphins, connected together and to the shore by means of light steel foot bridges at Port Victoria for the Admiralty. Contracts of the character enumerated above are very welcome in the Midlands just now, and hopes are entertained by many firms of securing additional works in the near future.

Iron and Steel and Tariffs.

At the Walsall Chamber of Commerce meeting on Monday a suggestion affecting the iron and steel trade was made by Mr. A. E. Hurst, who moved a resolution to the effect that the Chamber should make representations to the Tariff Advisory Committee that the best interests of the trade of the country would be served if attention were first given to those industries with no protection apart from the revenue tariff of 10 per cent., and that with regard to the minor trades under the Abnormal Importations Act—the duties under which are shortly to expire—the position might be met if the duties were renewed while the more important trades were being considered. Mr. Hurst said that there was an impression that the Tariff Commission proposed to give first attention to the smaller trades which had Protection under the Abnormal Importations Act. That course, he argued, would entail delay in dealing with much more important matters. If it were decided to increase duties for the benefit of the iron and steel trade increased employment would immediately be found for collieries and increased traffic for the railways.

Automobile Engineers' Reduced Profit.

The directors of Morris Motors, Ltd., the well-known Midland automobile engineers, in their annual report, express the opinion that trading results for the year 1931 are satisfactory, bearing in mind the world-wide depression, although the gross profit has shrunk by £586,965 to £1,020,563, which compares with £1,607,528 for the year 1930. These figures include net earnings from subsidiary companies and interest on industrial investments. The balance sheet total is £8,533,363, comparing with £9,061,339 a year ago. The dividend on ordinary shares, which are held privately, is halved at 5 per cent., free of income tax, and £259,331 is carried forward, as against £258,112 brought in.

Market Position.

Work has now been pretty generally resumed in Midland and Staffordshire mills and factories, although, in some cases, there is no certainty as to how long they will continue active. There is little reserve of orders at the majority of works, but a few firms are favourably placed. Nothing has arisen since the holidays to give any new momentum to the iron and steel industries and the market for these materials remains quiet. A few small orders have been given out, but demand is such as to afford no test of values. Quotations accordingly remain as in recent weeks. Some branches of Midland trade are experiencing a seasonable stimulus, but the basic industries have to adjust their activities to markets which are absorbing, in many cases, less than half the normal amount of of material. There is a superabundance of raw materials, and only in a very few departments of manufacture is there any pressure for deliveries. There was a fair attendance of producers and consumers on the Birmingham Exchange this week, but it signified more eagerness to probe the possibilities of the Quarterly Meeting due next week than to put through business at the present date. The portents for the quarterly gathering do not appear to be of an encouraging nature.

Raw Iron Prices.

Selling prices of Midland brands of pig iron are to remain unaltered during April. The Central Pig Iron Producers' Association met as usual on the eve of the new month to consider the position of the industry and revise selling prices in the light of new conditions, if any. It was decided to make no change in the basis of minimum selling rates as then existing, so that forge and foundry iron from local furnaces will cost this month: Northamptonshire forge, £2 17s. 6d.; No. 1 foundry, £3 5s. 6d.; No. 2, £3 4s. 6d.; No. 3, £3 2s. 6d.; No. 4, £3 1s. 6d.; Derbyshire forge, £3 1s.; No. 1 foundry, £3 9s.; No. 2, £3 8s.; No. 3, £3 6s.; No. 4, £3 5s., delivered at stations in the Black Country and subject to rebate. In the pig iron trade output is more than sufficient for the needs of the market, and the quarter just ended has proved a severe strain to furnacemen and merchants. Most of the blast-furnaces now in commission are working at minimum speed. Notwithstanding recent curtailments of production a certain proportion of the output of pig iron is going into stock. Furnacemen experience difficulty in persuading consumers to take delivery against existing contracts. There is, therefore, little probability of invigorating interest being taken at next week's gathering of ironmasters and their customers in second quarter requirements. Some attention is being given to the activities of the Commission to whom the scheme of tariffs has been referred respecting its views as to iron and steel imports, though local smelters are not affected in this market by foreign supplies. Continental pig iron is not competitive in this area, neither was it before the 10 per cent. general duty was introduced, but from a general point of view and as regards the effect upon steel semis and finished materials, the situation is of considerable moment. Derbyshire and Northamptonshire blast-furnacemen are not very pleased with the immediate prospects. Heavy foundries are buying very little material and the orders of makers of light castings have fallen away again. The forges call for hardly any iron. There is at date little confidence in the growth of spring business usual at this period of the year.

Steel.

Conditions continue dull in the steel trade, and there is little business passing, either in finished or semi-finished material. Steelmasters are closely following the movements of the Tariffs Commission, from which they hope to obtain considerable assistance in their efforts to combat foreign competition. At the moment stocks of imported iron and steel are not being augmeted. Material bought since the 10 per cent. duty was imposed is being shipped with as little delay as possible in view of the probability of a superimposed duty, and there are very large stocks in the hands of Black Country manufacturers. Re-rollers, in particular, are keeping a very watchful look-out for developments. Local steel works are operating on a small scale, as rolling programmes are very difficult to arrange. In no department is demand anything like up to normal. Quotations on 'Change this week showed no alteration from those recently given. In the case of finished material, the Association fixed level was firmly adhered to. As regards uncontrolled steel, boiler plates were named £8 10s., small re-rolled bars £6 7s. 6d. upwards, all-British bars £7 5s., mild steel billets £5 5s. to £5 7s. 6d., and sheet bars £5 to £5 5s. Recent orders which have come into this district should, in time, absorb additional steel, but in the structural department there is a dearth of orders and but poor prospects.

Staffordshire Bar Iron.

Ironmasters have improved their position very little as a result of the Easter vacation, and some mills have not yet resumed operations. Work is very irregular, especially in the merchant and common bar branches. Tonnages are small and there is hardly any chance of arranging forward production. Ironmasters are looking to the Quarterly Meeting in the hope that some business will develop therefrom, but they are not enthusiastic about prospects. Careful inquiries amongst users fail to elicit satisfactory answers as to future consumption. Makers of wrought iron tube strip are, perhaps, slightly better off for orders than they were, but output is not up to that at the opening of last quarter. Values in this department are maintained at £10 10s. to £10 12s. 6d. The quotation of £12 at makers' works for Staffordshire marked bars is unchanged, while Crown iron continues to sell at £9 5s. upward. Common bars for the nut and bolt and fencing trades are quoted £8 7s. 6d., but there is practically no demand. There is no call either for the cheap Belgian No. 3 iron quoted at just under £5 10s. per ton. Consuming works have ample material in hand and on order to last them for some time to come at the present rate of consumption.

Galvanised Sheets.

A mild improvement in buying of galvanised sheets on overseas account is to be recorded this week. Orders are more numerous, but there is no substantial increase in the tonnages required. Galvanised corrugated sheets of 24-gauge are held for £9 10s. per ton f.o.b. Liverpool. In the case of small home business quotations are rather higher. The demand for black sheets for the automobile industry also shows progress, and the district mills are in a little better position than before the recent holiday.

LANCASHIRE.

(From our own Correspondents.)

MANCHESTER.

Profits from Cable-making.

To be able to record an increase of profits, even if it be only a relatively slight increase, is no mean achievement these days. This has been the experience of British Insulated Cables, Ltd., the past year's operations having resulted in a profit of £589,610, compared with £576,593 for 1930. The explanation is, as the chairman, Sir Alexander Roger, pointed out at the annual meeting of the company at Liverpool, that the electrical industry has not felt the world depression so acutely as have many other businesses, although rationalisation and development appear also to have played an important part. For example, manufacturing operations have been extended in directions other than pure cable-making, this broadening the basis of the company's business, whilst measures of co-operation with other large cable-manu-

facturing concerns have been adopted. Work in connection with the Scottish grid scheme of the Central Electricity Board has, so far as the cable section is concerned, been completed, and another important contract completed by the company during the past year was in connection with the electrical track equipment for the Great Indian Peninsula Railway. The outlook for the cable-making industry, if not particularly bright from the point of view of immediate expansion, is certainly not discouraging, for Sir Alexander Roger is hopeful of continuing during the present year the experience of 1931. As to the more distant future, the view is expressed that the electrification of suburban railway services in this country cannot long be further deferred, and that when the proposition is taken up it will help forward the whole electrical industry immensely by loading the national "grid" and so reducing the incidence of capital costs and rendering possible the supply of cheaper power, to the advantage of industry generally.

The Lancashire Steel Corporation.

Having regard to the prevailing conditions of trading in the iron and steel industries during the past year, it will occasion little surprise that the operations of the Lancashire Steel Corporation, Ltd. have resulted only in a small profit relative to the capital involved. The Corporation, which was formed in 1930 to acquire the Partington Steel and Iron, the Pearson and Knowles, and the Wigan Coal and Iron businesses, is still in its initial stage, and the net earnings have been swallowed up in writing off expenses incidental to its formation. The development programme carried out during the year at the Corporation's works, principally at Irlam, on the Manchester Ship Canal, has been enormous, and the directors' report emphasises that the Corporation will be in a position to take full advantage of any revival of trade that may occur during the present year. It is stated that in 1931 orders were obtained in the face of severe competition, but at low prices, especially for small bars and hoops.

Non-ferrous Metals.

Marked weakness has again been in evidence in all sections of the non-ferrous metals markets during the past week, and whilst the appreciation in the value of the pound has continued to be a bearish influence, so far as prices are concerned, there is no doubt that the absence of anything in the nature of equilibrium between supplies and the demand for pretty well every description of non-ferrous metal has been the primary depressing influence. This has undoubtedly been the case with regard to tin. After the loss in the previous week bordering on £10 per ton, foreign brands have declined during the past week by a further £9. At one time there was some degree of recovery from the lowest points that had been touched in consequence of the wave of selling that had been experienced, but the improvement was short-lived, and the loss on balance since last report has been to the extent named. Although less pronounced than with tin, there has also been weakness in the copper section, with values lower by roughly £1 10s. per ton. Offers of the metal are much more than adequate to meet the continued poor demand, and the statistical outlook is still the reverse of satisfactory. Quiet conditions have been reported in respect of lead, although the loss in this case has only been to the extent of about 5s. per ton, with spelter also slow at prices which represent a decline on the week of roughly 10s. per ton.

Iron and Steel.

Very little contract buying of foundry iron can be reported, although so far as deliveries are concerned, there has been not much complaint of the present position relative to the experience during the last six months. Pig iron prices are fully steady, with Derbyshire, Staffordshire, and Cleveland brands of No. 3 at about 67s. per ton, delivered Manchester or equal distance, Derbyshire forge iron at 65s. 6d., Scottish pig at about 86s. 6d., and West Coast hematite at 81s. Buying interest in the case of finished iron, as it has been for some considerable time, is at a low ebb, but quotations keep up at £9 15s. per ton for Lancashire Crown quality bars and £10 5s. for best bars. With regard to steel, the aggregate demand this week has been extremely limited, and for no description of material are users disposed to operate on other than an early rolling basis, plates, bars, and constructional qualities all being in poor demand. Quotations keep up at about £8 12s. 6d. per ton for boiler plates, £8 17s. 6d. for tank plates, £8 15s. for joists, £8 7s. 6d. for sections, about £7 for small re-rolled bars, and £9 7s. 6d. for large bars. There is little call for imported products, and whilst very low rates are being nominally quoted on this market there is no doubt at all that business of any bulk could be placed at well below the prices that are named.

Barrow-in-Furness.

Hematite.

It is interesting to note that there was a dispatch from Ulverston this week of over 300 tons of hematite for Chester, and this is the first seaborne cargo that has left Ulverston for eighteen years. This means that the Ulverston channel in Morecambe is again available. Further shipments are likely. The iron ore trade is naturally very quiet, with so few furnaces in blast and with a very low demand from outside users. The steel trade continues to be quiet, but there is some likelihood of the rail departments starting in the course of a few weeks on orders already held.

Omnibuses Replace Trams.

On Tuesday the tram services in Barrow ceased, and omnibuses were introduced on all routes. During the last week the Barrow Corporation has added to its fleet of omnibuses eighteen double-decked vehicles, each with a seating capacity of forty-eight. Nine of them are petrol driven and the other nine have heavy oil engines. They are so constructed that the engines can be changed in a few hours. Barrow's original trams in the 'eighties were steam driven.

SHEFFIELD.

(From our own Correspondent.)

No Progress in Heavy Steel.

The condition of depression on the heavy side of the local steel trade is unrelieved. On the contrary, output and sales have shown a shrinking tendency for some months. While the number of open-hearth furnaces in commission has not been reduced, there is difficulty in finding a market for their output, and, owing to the lack of forward business, no certainty that the present rate of production will be maintained. There is very little work in heavy forgings and castings for shipbuilding or engineering. Railway companies, both at home and abroad, are still pursuing an economical policy, and giving out very few orders for axles, tires and springs. The amount of work on hand in the shops devoted to these products is only about one-third of the normal. Owing to reduced traffic, there is less wear and tear of rolling stocks than formerly, but at the same time it is probable that the railway companies are in need of much material which they would obtain if finances were better. In North Lincolnshire, the expansion of the basic steel trade, previously reported, is well maintained, and the present output is considerably in excess of last year's average.

Some Stronger Lines.

There are some branches of Sheffield trade which are doing well or fairly well, thus giving several touches of brightness to the general picture. The call for stainless steel, for cutlery, engineering, and manufacturing purposes, keeps up well, and there is also a good demand for heat-resisting and acid-resisting steels. The automobile industry continues to be one of the city's best customers. While its demands are not perhaps showing the progressive expansion of previous seasons, it is still taking large quantities of sheets, plates, bars, and castings for vehicles of various types. One of the most satisfactory departments at present is that of hot and cold wrought steel strip. Sheffield is well placed for supplying both kinds of this material, and the mills are now very busy. Since the beginning of the year there has been a largely increased call, especially for hot wrought strip, new uses for which are constantly being discovered. Business in the file trade has improved considerably of late. Another improving trade is that of hack-saws. This business has benefited from recent changes in tariffs and exchanges, and the effect of those new conditions is shown by the fact that the proprietors of a well-known American brand of hack-saws are negotiating for the purchase of a site in the Sheffield Lane Top district on which to erect a factory where employment will be provided for several hundred people, mostly women and girls.

Projectile Progress.

Sir Robert Hadfield, at the annual meeting of Hadfields, Ltd., last week, gave some interesting information about the success of a new type of armour-piercing projectile which his firm has just developed. He said that with this new type it had been found practicable to perforate and remain unbroken hard-faced armour of the latest and best quality of over 1ft. in thickness, inclined 30 deg., at a velocity equivalent to a range of no less than 15,000 yards. This was undoubtedly the finest result yet obtained with large-calibre armour-piercing projectiles, and showed that Sheffield's skill had not abated. The time occupied in perforating the armour-plate in question was just about one-two-hundredth of a second. As showing the difficulties of the time, he mentioned that the firm was working at considerably less than its normal capacity. Its steel capacity to-day, he said, was not far below that of the war output, the record amount of which, during 1917, was 3554 tons weekly, but now it was difficult to maintain even one-third of that output. A more satisfactory matter to which he called attention was the fact that, in connection with the construction of Sydney Harbour Bridge, the firm supplied more than 1100 tons of its "Era" manganese steel rails, representing a value of some £50,000. The total length of rails supplied was equal to 14½ miles of single track.

Cutlery and Plate.

There is a great deal of unevenness in the cutlery and plate trades. While some special branches are doing very well, the demand for ordinary lines, of good quality, through the regular distributing channels, is very poor, and conditions have probably never been so bad as they are to-day. It is declared that old-established businesses, doing a quality trade, are losing money. Demand is fairly brisk for attractive special lines suitable for gift and advertisement purposes, and the coupon trade continues to be responsible for the placing of substantial contracts. There are many inquiries for cheap cutlery to replace Continental makes that are no longer available. Some of these inquiries have already resulted in actual business, but this has been placed at severely cut prices, such as can be quoted only by small firms with low overhead charges. Exceptionally cheap pocket knives, which are both serviceable and attractive looking, are now being offered by Sheffield, and the organ of the Sheffield Chamber of Commerce states that merchants in Holland and Denmark are actively pursuing inquiries with the object of transferring their orders from Germany to Sheffield, as far as possible. A German firm has acquired premises in the city for the manufacture of cutlery. Sales of scissors have increased notably since the imposition of the Anti-dumping Duties, and increasing demand for safety razor blades, which has been previously noticed, still continues. There have been cuts in the prices of spoons and forks, following the adoption of labour-saving machinery by several large firms, and costs of low-grade plated goods are also being reduced by new methods of production.

Dock and Railway Progress.

Improvement schemes on which the L.N.E.R. Company is at present engaged include modernisations at Grimsby docks, one item being the installation of a new belt coaling plant at the Royal Dock. A contract for reinforced concrete piles and decking in connection with this plant has been placed with the Yorkshire Hennebique Contracting Company, Ltd., of Leeds, and the machinery, cranes, and belts are being supplied by Henry Simon, Ltd., of Stockport. The scheme of the railway company embraces the provision of the most modern type of coaling appliances procurable. Four berths, each capable of dealing with coal at a rate of 400 tons per hour, and two smaller berths, are to be provided. Coal will be tipped into hoppers on the shore from 20-ton wagons and transported to the berths through tunnels by an ingenious conveyor belt system. The scheme also involves extensive alterations to the railway, the filling in of the Alexandra Dock lock, and the running of six lines over the lock. A road subway is to be constructed beneath these rails to avoid a level crossing. In connection with the quadrupling of 11 miles of the main line between York and Northallerton, the L.N.E.R. has decided to construct entirely new station buildings at Beningbrough, Alne, and Otterington.

NORTH OF ENGLAND.

(From our own Correspondent.)

Trade Expansion.

There is much less apathy in industrial circles in the North of England, and the hopeful atmosphere which has been prevalent of late is fully maintained. The volume of business passing in the iron and steel trade still leaves much to be desired, but there are, nevertheless, signs of improvement in many directions. A gradual but steady improvement is taking place, and it is encouraging to record another increase in the iron and steel exports from the Cleveland district. The figures for the three months of the current year are: January, 30,293 tons; February, 37,388 tons; March, 42,579 tons. The increase is not confined to any one branch of the trade. It is true that foreign shipments of pig iron are down. This is entirely attributable to depressed conditions abroad, increased tariffs, import prohibitions, and currency restrictions. But any decline in the foreign trade is more than offset by increased deliveries to home ports, and the total pig iron shipments for March have reached 12,971 tons, compared with 10,468 tons in February, and 8436 tons in January. The foreign shipments of pig iron totalled 2625 tons, of which 1055 tons went to Denmark. Manufactured iron and steel shipments show a similar advance. In January 21,857 tons were despatched from the Cleveland district, in February 26,920 tons, and in March 29,608 tons. Moreover, the Australian market is open once more, there is a prospect of more business with Canada, and a continued expansion of trade is now confidently expected. Portuguese East Africa was the largest customer for finished iron and steel last month, with 2951 tons, while 2212 tons were sent to the Union of South Africa, 1722 tons to India, and 1126 tons to Siam.

Imports Down.

Another encouraging feature is the continued marked decline in iron and steel imports. Statistics presented at this week's meeting of the Tees Conservancy Commissioners reveal the effect of the import duties. During the month of March, when the duties became operative, only 5071 tons of pig iron and steel were brought into the port, compared with 14,471 tons in February and 16,726 tons in January. During the past five months 69,816 tons were imported, as compared with 70,204 tons in the corresponding period of 1930–31, and 31,266 tons in the pre-war period of 1913–14. Last month's imports comprised 2237 tons of pig iron, 2559 tons of crude sheet bars, billets, blooms and slabs, and 275 tons of plates, bars, angles, rails, sheets and joists.

Cleveland Iron Trade.

The Cleveland pig iron market is without any striking feature this week. Transactions show some slight improvement, but the total volume of business is not great. The whole of the current output, however, is being fully taken up, and signs of expansion in business are increasing. Prices are firmly maintained, No. 1 Cleveland foundry iron being 61s., No. 3 G.M.B. 58s. 6d., No. 4 foundry 57s. 6d., and No. 4 forge 57s.

Hematite Pig Iron.

There is a better demand for East Coast hematite pig iron. Renewal of deliveries to Wales is a gratifying feature, and further sales to Sheffield and the Midlands are looked for. Merchants are still selling mixed numbers at 63s. 6d., but are no longer disposed to shade that figure, and makers are asking a little higher price. No. 1 quality is at a premium of 6d. per ton.

Manufactured Iron and Steel.

The manufactured iron and steel trade has developed a little more activity, and heavy structural steel orders are coming forward more freely. There is, however, no hope of any early expansion in the demand for shipbuilding material. There is rather more business passing in the sheet trade. Prices are unaltered.

The Coal Trade.

A further illustration of the severity of foreign competition for coal orders abroad is afforded this week. For many years past the Lisbon Gasworks have bought Durham coal, but they have just concluded a contract for 21,000 tons of Westphalian fuel at 3d. per ton less, it is stated, than was asked for Durham coal. News is expected during the next few days of the allocation of one or two orders for steam coals to be supplied to large undertakings in Scandinavia. It will be interesting to learn how Polish coals have fared. The competition from that quarter does not seem quite so keen. In the first three months of the year, Polish sales in Northern Europe do not appear to have been so large as in the last quarter of 1931. This area is winning back some of the trade it lost in 1926, and

all the reductions which Poland has made in rail rates, miners' wages, &c., do not seem to have stayed the advance of British coal. There is little change to note in the Northumberland steam coal trade outlook so far as prompt business is concerned. For the first half of this month fitters are comfortably booked, and are holding for recent prices. For later holdings supplies are more plentiful, and buyers are not forcing the market. Best steams are in good tone for prompt at 13s. 6d. to 13s. 9d., but for other positions it is difficult to improve on 13s. 6d. Tyne prime steam coals are steady prompt, but forward are available at 12s. to 12s. 6d., according to individual positions. Durham prime steam are offered in moderate volume at 15s. Steam small remain plentiful at 8s. 6d. to 9s. The majority of Durham gas coal producers are only moderately booked, and lost time is still unavoidable at some of the pits. Fitters offer freely at the schedule prices, but fail to tempt customers. Best gas coals are quoted at 14s. 6d., and seconds at 13s. 3d. to 13s. 6d. There is a well-sustained demand for all favourite brands of bunker coal at a firm range of values. For good ordinary, however, inquiry is only moderate, and with ample stocks and many pits idle, sellers offer at minimum prices of 13s. First qualities realise 13s. 9d. to 14s. Coking unscreened stocks are heavy, although output is restricted. Prices rule easy at 13s. to 13s. 9d. Coking smalls are moderately booked, but quoted steady at 12s. 6d. to 13s. 3d. The coke market shows no sign of increased steadiness—rather the reverse. Inquiry is meagre, and stocks of all descriptions are slowly accumulating. Best gas coke is now on sale at 18s. 3d., while patent oven coke is a dull trade at 15s. 3d. to 16s., and superior makes at 18s. to 20s.

Coal Trade Ascertainments.

A slight improvement in the Durham coal industry is indicated in the ascertainment of the state of trade for the month of February. This shows an available surplus of 35·89 per cent. above the basis, compared with 35·39 per cent. in January. The minimum percentage on the basis being 65, the owners are required to make up the balance of 29·11 per cent. The figures for the Northumberland coalfield show an available surplus of 21·31 per cent. above the basis, as compared with 18·71 per cent. for January. The minimum for the county being 40 per cent. on the basis the owners are required to make up the difference of 18·69 per cent.

Wages Advance.

The average net selling price of manufactured iron in the North of England for the two months ended February showed a small increase, and under the sliding scale arrangement an increase of 2½ per cent. in puddling and other forge and mill wages has been conceded for the next two months.

SCOTLAND.

(From our own Correspondent.)

Shipbuilding.

THE idleness witnessed during the first three months of this year has been a unique experience in the history of the shipbuilding industry. The total tonnage launched during that period only amounted to six vessels of 8637 tons aggregate, of which the March output accounts for three vessels of 1399 aggregate tons. In face of the lack of new contracts, it seems safe to say that this year will establish a record for low output, and will eclipse that of 1931. A fair inquiry was reported during March, but the only contracts placed were for a dredger for the Soviet Government and a floating dock for service in South Africa.

Steel.

With the dearth of orders for shipbuilding materials, steel makers have to rely more on the export markets to keep mills in operation. Inquiries are fairly good, but firm orders are scarce. It is understood, however, that fairly substantial orders have been received from Canada, and one from Scandinavia. Sheet makers were not so busy during the month of March, but inquiries from abroad have improved, especially for light sheets. Canada is expected to purchase more extensively, and prospects in other directions are more favourable. Galvanised descriptions are quiet.

Tubes.

Business in tubes has been very quiet for some time, but with the settlement of the Cartel arrangements things are likely to improve. The success of Stewarts and Lloyds in securing the contract from the Iraq Petroleum Company has given considerable satisfaction. The tubes will be made in the Glasgow and Birmingham areas, and the 60,000 tons of steel necessary for the contract will be made in Stewarts and Lloyds' works.

Iron.

Bar iron continues to suffer from trade depression, low-priced Continental iron and competition from steel bars. Makers hope to benefit from improved conditions in the tube trade, and a renewal of the seasonal demand for skelp for Canada is anticipated. Makers of re-rolled steel bars experience keen opposition from the Continent, and despite considerable price-cutting, business is decidedly slow. Prices are nominally unchanged at £6 5s. home and £6 2s. 6d. per ton for re-rolled steel bars. The output from the six pig iron furnaces in blast in Scotland is ample to meet all requirements, especially in the face of sustained competition from Indian and English material.

Scrap.

Scrap material is difficult to move, and prices continue to weaken, with heavy steel at about 37s. 6d. and cast iron machinery 50s. to 52s. 6d. per ton.

Coal.

The restriction of imports into Continental countries is telling heavily against Scottish fuel, especially East of Scotland sorts. Business on home account continues to decrease and exports are of a day-to-day character. All fuels, with the exception of Lanarkshire prime splints, are easily obtained for immediate shipment and prices as a rule are a matter of arrangement. Washed stuffs are irregular. Aggregate shipments amounted to 211,696 tons, against 249,267 tons in the preceding week and 205,981 tons in the same week last year.

Coal-loading Machines.

It is announced that Mavor and Coulson, Ltd., of Glasgow, have entered into an arrangement with the Joy Manufacturing Company, of Franklin, Pennsylvania, whereby the Glasgow firm will be enabled to construct the M. and C. Joy loaders in this country for sale throughout the world, except in the United States. A start has already been made in the construction of these products, and the first half-dozen loaders are approaching completion, some for underground and some for surface service. Gearing and other mechanical parts are made at Broad-street, Bridgeton, Glasgow, and the structures at the East Kilbride works.

WALES AND ADJOINING COUNTIES.

(From our own Correspondents.)

The Coal Trade.

SHIPMENTS of coal for the last fortnight have been adversely affected by the holidays, as will be seen from the fact that last week the total for the six ports under the control of the Great Western Railway Company came to only 268,180 tons, compared with 366,970 tons for the preceding week and with 400,852 tons for the corresponding period of last year. The figures for the current week should, of course, be better, as work has proceeded on normal lines. On Monday the position was that there were twenty-one vacant loading berths at Newport, Cardiff, Penarth, and Barry, whereas at Swansea and Port Talbot, where anthracite coals mainly are shipped, there were nine steamers waiting to get into loading berths. Although the general complaint on the market is that trade is exceptionally slack, still it is not as bad as would appear to be the case on the surface. The chartering of tonnage continues on moderately active lines, but when business is concentrated more in the hands of a few of the leading combines, there is naturally less general activity. So far as contract operations are concerned, the most noteworthy is an order from the Buenos Aires electricity works for 300,000 tons of sized coals to be delivered over the whole of 1933, the buyers having the option of increasing the quantity to 360,000 tons. This business is at the present time held by one of the leading Cardiff concerns, but there will unquestionably be very keen competition from Germany for this next contract. Reference was made last week to the contract which the Germans had secured for 75,000 tons of coal for the Brazilian Central Railways, and to the denial which had been issued that the exchange of coffee for coal was involved. Since then it is interesting to note that a Reuter message from San Paulo confirms the first report to hand, and states that the Brazilian Minister of Finance had made the signature of the contract for German coal dependent on the Germans buying Brazilian coffee. Up to now, no news has come to hand regarding one or two small contracts pending for supplies of coal for Portuguese undertakings. Spanish business is rather on the quiet side, but it is now definite that the increase in the Spanish transport tax from 1 to 2 pesetas is in force. This came into operation as from the 1st inst., which is what was expected.

The Outlook.

Despite the comparative quietness of the coal export trade, those who are most closely in touch with it are far from pessimistic regarding the future. If many of the foreign barriers could be broken down, the prospects would, of course, be much brighter, but apart from this, there is much speculation as to what may be the position in the event of the Coal Mines Act and especially Part I. being amended, thus providing for the abolition of restrictions in regard to prices and output. Hopes are, of course, entertained that no time will be lost in the matter of a settlement of the question of wage conditions and hours of work in the coalfield, in view of the fact that unless action is taken the seven-hour-day operates automatically after July 7th. The coal industry cannot face this change without great anxiety, so that no time should be lost if trade is not to suffer considerable dislocation by the uncertainty that must arise. The subject was discussed at a joint meeting between the Executive Council of the South Wales Miners' Federation and Welsh Labour Members of Parliament at the end of last week, when it is reported that the majority of those present displayed more anxiety about the question of wages than that of hours of employment. The miners' leaders desire not only the continuance of the existing rate of wages, but an improved scale, but no definite action was taken at this meeting. It is understood that there is to be another meeting of the Council, when it is hoped that definite instructions will possibly be given to the South Wales representatives regarding the policy to be adopted.

Shipment of Washed Duff.

At the recent annual meeting of the Cardiff Chamber of Commerce, the President, Mr. J. W. Duncan, referred to the change in the character of the coal shipped at the South Wales ports by the increase in the quantities of washed duff, and expressed his view that the shipping appliances should be so adapted as to be able to deal as expeditiously with its loading as that of ordinary coal. Since then it has, however, been pointed out that it was only at the end of last year that agreement was come to between the G.W.R. Company and the traders regarding special payment for the loading of washed coal, and the G.W.R. Company then immediately placed orders for a number of special digging-out machines to be provided at the South Wales ports, which will deal quickly and efficiently with the washed duff. These machines are expected to be working shortly. They consist of mechanical diggers or spades to be attached to the present coal-shipping machines, and are capable of clearing a wagon-load of washed duff at the same speed as ordinary coal is shipped.

Cardiff Shipping.

According to the latest returns, 293 steamers of a gross tonnage of 1,067,709 are owned by members of the Cardiff District of the Shipping Federation. This compares with 311 ships of 1,145,214 gross tons in 1931. The list is headed by the Hain Steamship Company, Ltd., with 40 vessels of 195,695 gross tons, the Reardon Smith Line coming second with 26 vessels of 134,207 gross tons.

Trade at South Wales Docks.

The G.W.R. Company's returns of traffic at the docks controlled by them in this channel show that for the four weeks ended March 13th imports and exports came to 2,097,046 tons, which compares with 2,263,478 tons for the corresponding period of last year. From January 1st to March 13th, the aggregate trade amounted to 5,294,660 tons, as against 4,371,979 tons for the same period of last year, and with 8,338,194 tons for the same period of 1930.

Current Business.

New business in steam coals is slow to come along for prompt shipment, but still quite a number of collieries are not at all badly placed for an outlet, though they could, of course, deal with a greatly increased demand. Dry coals are relatively the steadiest section of the market, all other descriptions being easily obtainable. Patent fuel moves off rather slowly, but coke is steady. Pitwood continues to be offered freely, and there is no improvement in prices.

CATALOGUES.

ALFRED HERBERT, Ltd., Coventry.—Sixth edition of "Turret Lathe Tools."

BRYAN DONKIN COMPANY, Ltd., Chesterfield.—Catalogue on high-pressure gas governors and regulators.

COCHRAN AND CO., ANNAN, Ltd., 137, Victoria-street, S.W. 1.—Pamphlet 39 on Diesel exhaust gas boilers.

NEWMAN, HENDER AND CO., Ltd., Woodchester, Glos.—Booklet entitled "Uniformly Sound Castings."

BROOKHIRST SWITCHGEAR, Ltd., Chester.—A booklet dealing with the control of electrically driven pumps and compressors.

ELLIOTT BROTHERS (London), Ltd., Century Works, Lewisham, S.E. 13.—Particulars of the Siemens direct reading humidity meter.

PERSONAL AND BUSINESS ANNOUNCEMENTS.

MESSRS. LIVESEY, SON AND HENDERSON, London, inform us that, after an association with the firm extending over some fifty years, Sir Harry Livesey retired from it on March 31st, 1932. The business of the firm will be carried on by the three remaining partners under the style of Livesey and Henderson.

THE BRITISH THOMSON-HOUSTON COMPANY announces the following appointments:—Mr. J. W. Leach, M.I.E.E., has been appointed manager of the company's London office, in succession to the late Mr. A. H. Walton. He entered the service of the company at Rugby in 1904, and since 1920 has assisted the late Mr. Walton as sales engineer on the London office staff. Mr. E. Sayers has been appointed sales manager of the Coventry works, in succession to the late Mr. E. Garton. Mr. Sayers commenced his business career with Edmundson's Electricity Corporation, entering the service of the B.T.H. Company in 1905. Mr. P. L. Edwards, B.Sc. (London), has been appointed acting manager of the company's Dublin and Belfast offices, in succession to the late Mr. W. F. Haldane. Mr. Edwards served his engineering apprenticeship with Harland and Wolff, Ltd., of Belfast, and has spent the whole of his business life in Ireland.

CONTRACTS.

THE D.P. BATTERY COMPANY, Ltd., Bakewell, has in hand at the present time two large contracts for telephone exchanges in the London area, namely, the London Trunk and the Kensington Exchanges. The order for the first-named was placed through Standard Telephones and Cables, Ltd., and covers the supply of two batteries, each having a capacity of 7800 ampère-hours. In the latter case the order was placed through the General Electric Company, and covers two batteries having a capacity of 9890 ampère-hours, with an ultimate capacity of 14,620 ampère-hours.

INTERNATIONAL ALUMINIUM COMPETITION, 1931.—We have received from the British Aluminium Company, Ltd., a brochure giving the results of the first competition, organised in 1930 by the International Aluminium Bureau, with the object of finding and rewarding inventions promising developments in the uses of aluminium and its alloys. There were over 300 entries, and although many of the suggestions contained interesting proposals showing considerable knowledge of the properties of the metal, the judges did not consider any of sufficient merit to receive the special award of 50,000f. Two prizes of 25,000f. were given, the first to Mr. C. Szmukler, of Megisseries Reynier, of Grenoble, whose entry concerned the use of aluminium and duralumin in the glove industry. Mr. de Haes, with a design for a finned radiator, shared the second prize of 25,000., with Dr. Hempel, who discussed the question of the tubular radiator. Abstracts of several other suggestions of interest are also given. The Bureau announces that owing to the success of the first competition, another is being organised for 1932. Helpful literature on light alloys will be sent on application to the British Aluminium Company, Ltd., Adelaide House, King William-street, E.C. 4, and the new rules of the competition are obtainable from the International Aluminium Bureau, 23 *bis*, Rue de Balzac, Paris, France.

Current Prices for Metals and Fuels.

IRON ORE.

N.W. Coast—	
(1) Native	16/6 to 20/-
(1) Spanish	17/- to 22/6
N.E. Coast—	
Native	18/- to 21/-
Foreign (c.i.f.)	16/6

PIG IRON.

	Home. £ s. d.	Export. £ s. d.
(2) Scotland—		
Hematite	3 8 6	—
No. 1 Foundry	3 12 0	—
No. 3 Foundry	3 9 6	—
N.E. Coast—		
Hematite Mixed Nos.	3 3 0	3 3 0
No. 1	3 3 6	3 3 6
Cleveland—		
No. 1	3 1 0	3 1 0
Siliceous Iron	3 1 0	3 1 0
No. 3 G.M.B.	2 18 6	2 18 6
No. 4 Foundry	2 17 6	2 17 6
No. 4 Forge	2 17 0	2 17 0
Mottled	2 16 6	2 16 6
White	2 16 6	2 16 6
Midlands—		
(c) Staffs.—	(*Delivered to Station*).	
All-mine (Cold Blast)	—	—
North Staffs. Forge	3 1 0	—
„ „ Foundry	3 6 0	—
(c) Northampton—		
Foundry No. 3	3 2 6	—
Forge	2 17 6	—
(c) Derbyshire—		
No. 3 Foundry	3 6 0	—
Forge	3 1 0	—
(?) Lincolnshire—		
No. 3 Foundry	—	—
No. 4 Forge	—	—
Basic	—	—
(4) N.W. Coast—		
N. Lancs. and Cum.—		
Hematite Mixed Nos.	3 15 6 (a) / 4 0 6 (b) / 4 5 6 (c)	—

MANUFACTURED IRON.

	Home. £ s. d.	Export. £ s. d.
Scotland—		
Crown Bars	9 15 0	9 5 0
Best	—	—
N.E. Coast—		
Iron Rivets	11 5 0	—
Common Bars	10 0 0	—
Best Bars	10 10 0	—
Double Best Bars	11 0 0	—
Treble Best Bars	11 10 0	—
Lancs.—		
Crown Bars	9 15 0	—
Second Quality Bars	8 5 0	—
Hoops	12 0 0	—
S. Yorks.—		
Crown Bars	9 15 0	—
Best Bars	10 15 0	—
Hoops	12 0 0	—
Midlands—		
Crown Bars	9 5 0 to 10 7 6	—
Marked Bars (Staffs.)	12 0 0	—
Nut and Bolt Bars	8 7 6	—
Gas Tube Strip	10 10 0 to 10 12 6	—

STEEL. (*d*)

	(6) Home. £ s. d.	(7) Export. £ s. d.
(5) Scotland—		
Boiler Plates (Marine)	9 0 0	8 10 0
„ „ (Land)	—	—
Ship Plates, ½in. and up	8 15 0	7 15 0
Sections	8 7 6	7 7 6
Steel Sheets, ¼in.	7 15 0	7 15 0
Sheets (Gal. Cor. 24 B.G.	10 15 0	10 0 0

STEEL (*continued*).

	Home. £ s. d.	Export. £ s. d.
N.E. Coast—		
Ship Plates	8 15 0	7 15 0
Angles	8 7 6	7 7 6
Boiler Plates (Marine)	10 10 0	—
„ „ (Land)	10 0 0	—
Joists	8 15 0	7 7 6
Heavy Rails	8 10 0	—
Fish-plates	12 0 0	—
Channels	10 5 0	£9 to £9 5s.
Hard Billets	7 2 6	—
Soft Billets	5 10 0	—
N.W. Coast—		
Barrow—		
Heavy Rails	8 5 0	—
Light Rails	8 10 0 to 8 15 0	—
Billets	6 10 0 to 9 0 0	—
Manchester—		
Bars (Round)	9 7 6	—
„ (Small Round)	7 0 0	—
Hoops (Baling)	10 0 0	9 15 0
„ (Soft Steel)	9 0 0	8 15 0
Plates	8 17 6 to 9 2 6	—
„ (Lancs. Boiler)	8 12 6	—
Sheffield—		
Siemens Acid Billets	9 2 6 (basis)	—
Hard Basic	8 2 6 and 8 12 6	—
Intermediate Basic	6 12 6 and 7 2 6	—
Soft Basic	6 0 0	—
Hoops	9 10 0 to 9 15 0	—
Soft Wire Rods	7 10 0	—
Midlands—		
Small Rolled Bars (all British)	7 5 0 to 7 15 0	—
Small Re-rolled Bars	6 7 6 to 6 10 0	—
Billets and Sheet Bars	5 5 0 to 5 10 0	—
Galv. Sheets, f.o.b. L'pool	9 10 0	—
(2) Staffordshire Hoops	9 10 0	—
(d) Angles	8 7 6	—
(d) Joists	8 15 0	—
(d) Tees	9 7 6	—
(d) Bridge and Tank Plates	8 17 6	—
Boiler Plates	8 10 0	—

NON-FERROUS METALS.

Swansea—	
Tin-plates, I.C., 20 by 14 f.o.b.	16 -
Block Tin (cash)	109 0 0
„ (three months)	111 0 0
Copper (cash)	30 10 0
„ (three months)	30 8 9
Spanish Lead (cash)	11 1 3
„ „ (three months)	11 7 6
Spelter (cash)	10 17 6
„ (three months)	11 5 0
Manchester—	
Copper, Best Selected Ingots	35 0 0
„ Electrolytic	36 0 0
„ Strong Sheets	63 0 0
„ Tubes (Basis Price), lb.	0 0 10
Brass Tubes (Basis Price), lb.	0 0 9¼
„ Condenser, lb.	0 0 11½
Lead, English	13 7 6
„ Foreign	11 7 6
Spelter	11 10 0
Aluminium (per ton—raw ingot)	£95

FERRO ALLOYS.

	Per Ton.	Per Unit.
Tungsten Metal Powder	2/4 per lb.	
Ferro Tungsten	2/- per lb.	
Ferro Chrome, 4 p.c. to 6 p.c. carbon	£26 8 6	7/-
„ „ 6 p.c. to 8 p.c.	£23 10 0	7/-
„ „ 8 p.c. to 10 p.c.	£23 0 0	6/6
„ „ Specially Refined		
„ „ Max. 2 p.c. carbon	£40 0 0	10/-
„ „ „ 1 p.c. carbon	£55 0 0	12 -
„ „ „ 0·70 p.c. carbon	£57 10 0	13/-
„ „ „ carbon free	11d. per lb.	
Metallic Chromium	3/1 per lb.	
Ferro Manganese (per ton)	£11 0 0 for home	
„ „ „	£11 10 0 for export	
„ Silicon, 45 p.c. to 50 p.c.	£12 0 0 scale 5/- per unit	
„ „ 75 p.c.	£17 15 0 scale 7/- per unit	
„ Vanadium	12/9 per lb.	
„ Molybdenum	6/3 per lb.	
„ Titanium (carbon free)	9d. per lb.	
Nickel (per ton)	£250 to £255	
Ferro Cobalt	10/- per lb.	

FUELS.

SCOTLAND.

	Export.
Lanarkshire—	
(f.o.b. Glasgow)—Steam	13/- to 13/3
„ „ Ell	14/-
„ „ Splint	14/- to 16/-
„ „ Trebles	12/6
„ „ Doubles	10/6
„ „ Singles	9/-
Ayrshire—	
(f.o.b. Ports)—Steam	13/-
„ „ Jewel	16/6
„ „ Trebles	12/6
Fifeshire—	
(f.o.b. Methil or Burnt island)—Steam	11/- to 12/-
Screened Navigation	16/6
Trebles	12/6 to 13/6
Doubles	10/- to 10/3
Singles	9/3 to 9/6
Lothians—	
(f.o.b. Leith)—Best Steam	11/6
Secondary Steam	11/-
Trebles	11/- to 11/6
Doubles	10/-
Singles	9/6

(8) N.W. Coast— ENGLAND.

	Export.
Steams	21/9
Household	32/6 to 51/8
Coke	20/- to 22/6
Northumberland—	
Best Steams	13/6
Second Steams	12/3 to 12/6
Steam Smalls	8/6
Unscreened	12/6 to 13/-
Household	27/- to 39/-
Durham—	
Best Gas	14/6
Second	13/3 to 13/6
Household	25/- to 37/-
Foundry Coke	24/-

Sheffield—	Inland.	Export.
Best Hand-picked Branch	26/6 to 27/6	—
South Yorkshire Best	22/- to 23/-	—
Derbyshire Best Bright House	22/- to 23/-	—
Screened House Coal	19/- to 20/6	—
Best Screened Nuts	17/- to 18/-	—
Small Screened Nuts	14/6 to 15/6	—
Yorkshire Hards	16/- to 18/-	—
Derbyshire Hards	16/- to 18/-	—
Rough Slacks	8/6 to 9/6	—
Nutty Slacks	7/- to 8/6	—
Smalls	5/- to 6/-	—
Blast-furnace Coke (Inland)	12/- to 12/6 on rail at ovens	
Furnace and Foundry Coke (Export), f.o.b., 18/- to 18/6		

(9) SOUTH WALES.

Cardiff—	
Steam Coals:	
Best Smokeless Large	19/6 to 19/9
Second Smokeless Large	18/9 to 19/6
Best Dry Large	19/- to 19/6
Ordinary Dry Large	17/9 to 18/3
Best Black Vein Large	18/3 to 18/6
Western Valley Large	17/9 to 18/-
Best Eastern Valley Large	17/7½ to 17/9
Ordinary Eastern Valley Large	17/3 to 17/6
Best Steam Smalls	13/- to 13/6
Ordinary Smalls	11/- to 13/-
Washed Nuts	19/- to 25/-
No. 3 Rhondda Large	19/6 to 19/9
„ „ Smalls	15/- to 16/-
No. 2 „ Large	17/- to 17/3
„ „ Through	15/6 to 16/-
„ „ Smalls	14/- to 14/3
Foundry Coke (Export)	22/6 to 36/6
Furnace Coke (Export)	17/- to 18/-
Patent Fuel	19/- to 19/3
Pitwood (ex ship)	18/9 to 20/6
Swansea—	
Anthracite Coals:	
Best Big Vein Large	36/- to 38/6
Seconds	27/- to 32/6
Red Vein	22/6 to 27/6
Machine-made Cobbles	41/6 to 48/6
Nuts	40/- to 48/6
Beans	28/6 to 32/6
Peas	18/6 to 21/-
Breaker Duff	8/6 to 9/6
Rubbly Culm	8/3 to 8/9
Steam Coals:	
Large	20/- to 20/6
Seconds	18/- to 20/-
Smalls	11/6 to 13/-
Cargo Through	16/- to 17/6

(1) Delivered. (2) Net Makers' Works. (3) f.o.b. Makers' Works, approximate. (4) Delivered Sheffield. (5) Glasgow, Lanarkshire and Ayrshire. (6) Home Prices—All delivered Glasgow Station. (7) Export Prices—f.o.b. Glasgow. (8) Except where otherwise indicated, coals are per ton at pit for inland and f.o.b. for export, and coke is per ton on rail at ovens and f.o.b. for export. (9) Per ton f.o.b. (*a*) Delivered Glasgow. (*b*) Delivered Sheffield. (*c*) Delivered Birmingham. (*d*) Rebate; Joists (minimum), 22/6; Ordinary Ship, Bridge, and Tank Plates and Seconds, 15/- if home consumers confine purchases from associated British Steel Makers. (*e*) Delivered Black Country Stations.

French Engineering Notes.

(From our own Correspondent in Paris.)

Machinery Imports.

INCREASING dissatisfaction is being caused amongst importers by the quotas which favour some countries at the expense of others. In this latter category of exporting countries Great Britain and the United States are particularly unfortunate. The American Chamber of Commerce in Paris and the American Importers' Association have protested strongly against the conditions under which, they say, it has become impossible to do business with France, and they have appealed to the American President to take immediate steps for reprisals in conformity with the cause in the Tariff Bill against discrimination. If it can be proved that there is discrimination the matter becomes serious, and on the face of it there would seem to be indirect discrimination, because the allotments are made in proportion to the quantity of goods imported into France from different countries during a stated period. By taking such imports as a basis the French Government is discriminating in favour of countries which, by its own admission, have been dumping goods into France. It is recognised that German makers have secured a strong hold on the French market because they offered machines at prices much below those that could be accepted by their British and other competitors, and there is every indication that German firms have aimed at getting business rather than at making profits. By fixing and renewing quotas in this way the French Government favours certain countries which have sacrificed prices in order to get trade. If the quotas were distributed to different countries according to their respective capacities of production some of the objectionable features of the system would be removed.

Steel Import Quotas.

As the result of negotiations between French and Belgian steel makers, the following import quotas have been fixed for the period between March 20th and June 30th :—Rolled and forged iron and steel : Belgium and the Grand Duchy of Luxemburg, 15,250 quintals per month ; Germany, 14,310 quintals ; other countries, 190 quintals. Steel strip : Belgium and Luxemburg, 950 quintals a month and other countries, 230 quintals. Silicon steel sheets : Belgium and Luxemburg, 262 quintals a month ; Germany, 152 quintals ; Great Britain, 117 quintals ; United States, 29 quintals ; other countries, 23 quintals. Planished steel sheets for motor car bodies : Germany, 1240 quintals a month ; United States, 600 quintals ; Great Britain, 120 quintals ; other countries, 40 quintals. The quintal is equal to 1·97 cwt. The restriction of rolled iron and steel imports is regarded as necessary for the operation of the new groups of French steel makers and mill and forge owners who have arranged to limit their production to requirements and to maintain prices. There is, nevertheless, some difficulty arising out of the collection of orders by a central office, which distributes them to producers according to their quotas, because customers have the right to select the works from which they require their material, and most of the orders are consequently notified for a few leading firms whose quotas of production are soon filled.

Warm Water Energy.

Another method of producing a difference of water temperature in hot climates for the driving of low-pressure turbines is described by Dr. Barjot, who has carried out experiments in the South of France with water in a reservoir with the bottom dead black. The reservoir is filled with water taken from the sea at a temperature of 20 deg. Cent. and is covered with a film of oil from 4½in. to 6in. thick. On a hot day in June the temperature of the water rises to about 50 deg. Cent., while a similar volume of water without the oil film has a temperature of 30 deg. to 35 deg. Cent. and loses by evaporation 1 cubic centimetre for every square centimetre of surface. With a thermodynamic efficiency of 2·5 per cent., Dr. Barjot declares that in tropical countries a reservoir 50 m. square containing water covered with a film of oil in proximity to a river or other water supply can produce daily 200 kWh.

Colonial Sloops.

The "Dumont-d'Urville" is one of a dozen sloops which are being constructed for the Colonial service. It underwent its trials at Lorient last week, when it attained a speed of 17·5 knots, or 2·5 knots more than the contract speed. The sloops have a length of 98 m. and a width of 12·5 m. Their displacement is 2000 tons. Propelled by two oil engines, each of 1600 horse-power, they have a range of action of 13,000 nautical miles at 10 knots. They will carry three guns of 130 mm., four anti-aircraft guns and six machine guns. They can also carry fifty mines and a seaplane. The part of the vessel above water is constructed of high-resistance steel.

Water Sterilisation.

Work will be started shortly at Nancy upon the construction of filtering beds and the laying down of an ozone plant for sterilising 100,000 cubic metres of river water a day. The ozone method of sterilising water has not made much headway in France on account of the cost, but in the case of Nancy the arrangements for distributing current will allow of supplies under conditions that will bring the cost of sterilisation to what is expected to be a reasonably economical figure.

Steel Prices.

In the absence of any factor that may help to revive confidence on the international market the improvement in sterling has had no effect in stimulating business in steel, and prices continue to weaken. On the Brussels Exchange bars are down to £2 6s. gold per metric ton ; joists of Continental sections to £2 5s., and sheets to £2 19s. The efforts to induce the dissentient steel makers in Belgium to accept the terms for the reconstruction of the Steel Cartel have so far been unsuccessful, and meanwhile Germany is prepared to impose import quotas on steel products unless something is done immediately to put the Continental steel trade on a more satisfactory basis.

British Patent Specifications.

When an invention is communicated from abroad the name and address of the communicator are printed in italics.

When an abridgment is not illustrated the Specification is without drawings.

Copies of Specifications may be obtained at the Patent Office Sale Branch, 25, Southampton-buildings, Chancery-lane, W.C. at 1s. each.

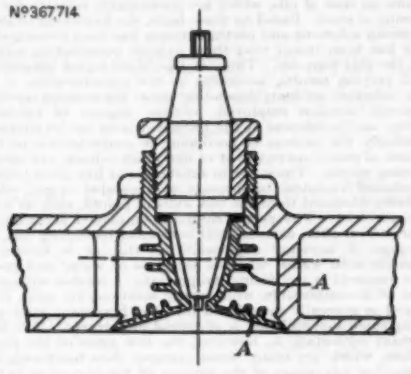
The date first given is the date of application ; the second date, at the end of the abridgment, is the date of the acceptance of the complete Specification.

INTERNAL COMBUSTION ENGINES.

367,714. July 28th, 1931.—SPARKING PLUGS, A. Kegresse, 156, rue Armand Silvestre, Courbevoie, France.

This is a very brief specification, of which the essence

Nº367,714



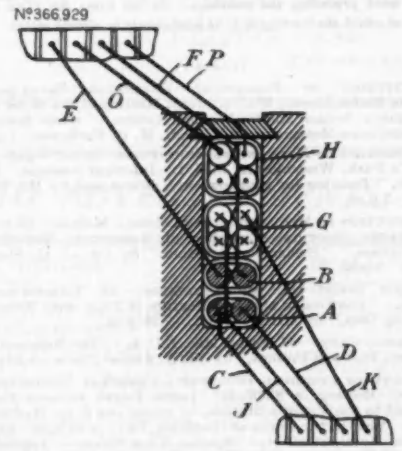
amounts to the provision of fins, such as those shown at A A, for the dissipation of heat from the sparking plug casing to the surrounding water jacket.—*February 25th*, 1932.

DYNAMOS AND MOTORS.

366,929. October 4th, 1930.—WINDINGS FOR D.C. DYNAMO ARMATURES, Julius Pintsch Aktiengesellschaft, of Andreasstrasse 71/73, Berlin, O.27, Germany.

The object of this invention is to provide an improved armature for a direct-current generator employing an increased number of commutator segments per slot which employs more than two superposed coil sides per slot. For the sake of clearness, the commutator is shown as divided into two separate parts, and it will be understood that these two parts are merely different parts of the same commutator. A and B represent coil sides, each having a single layer consisting of two parallel wires or conductors wound side by side, of which the lower one A belongs to a coil extending to the left, and the upper one B to a coil extending to the right. The two wires of coil side A are joined by connections C and D in the usual manner with separate commutator segments, which, however, are not, generally speaking, adjacent each other, as is the usual case, but are separated by an intermediate segment. The same applies to the segments joined with the ends of the wire of coil side B by connections E and F. Each conductor of coil sides A and B is connected at the other end of the armature to a wire

Nº366,929



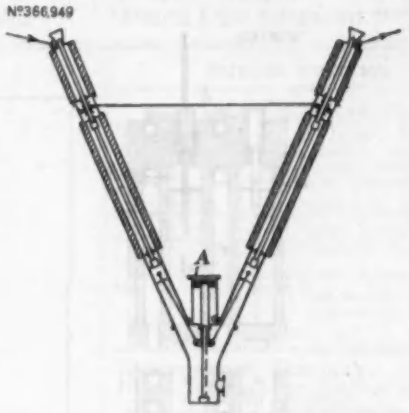
of a corresponding coil side in another slot, and thence again to another commutator segment, so that in tracing out this part of the winding there will be two armature conductors in series between consecutive connections to the commutator. The directions in which the wires or conductors—not the directions of the currents—are wound, are indicated by dots and crosses. G and H are also coil sides, each consisting, however, of four wires or conductors, of which each two situated side by side are wound together in parallel relationship. In this case the winding is commenced with the upper wires of coil side G, which return across the armature as the lower wires of a coil side—not shown—corresponding to H, but disposed to the left. They continue as the lower wires of coil side G and finally return across the armature as upper wires of the coil side—not shown—corresponding to H. The two coil sides are then placed in slots separated by a pole pitch. The ends J, K, O, and P, of the two windings G and H are connected to commutator segments alternating with those connected to the coil sides A and B. Thus in tracing out this part of the winding there will be four armature conductors in series between consecutive connections to the commutator.—*February 4th*, 1932.

SWITCHGEAR.

366,949. October 31st, 1930.—ELECTRIC GAS BLAST SWITCHES, *International General Electric Company, Inc., of* 120, *Broadway, New York, U.S.A.*

For interrupting polyphase alternating-current circuits, and also for H.T. single-phase current, gas blast circuit breakers are used. They are composed of several individual switches in series. In this case the breaks at the individual switches are arranged in such a manner that the gas blast can flow away freely towards one side. Consequently, measures must be taken to ensure that the gas blasts at the individual breaks do not come in contact with one another. According to the invention, this problem is solved by the individual switch poles being arranged obliquely in relation to one another, as shown, and the points of interruption are located at the free ends of the arms of the angle formed by the switch poles. In this case the gases will radiate from the individual poles, and will have little occasion to come in contact with one another. At the same time, the points of highest

Nº366,949



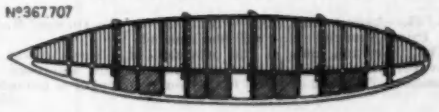
potential are at the greatest distance apart from one another. It is important that in the case of a switch having several individual breaks that all the moving contacts should be actuated simultaneously with great accuracy, and, according to the invention, a common centrally located driving member, such as a piston A, is employed, with which the movable contacts are pivotally connected, through guide rods. A further advantage of such an arrangement is that the conducting and distribution of the gas blast for extinguishing the arcs can be effected from the common gear casing.—*February 1st*, 1932.

AERONAUTICS.

367,707. July 21st, 1931.—LIGHTER-THAN-AIR CRAFT, Luftschiffbau Zeppelin Gesellschaft, mit beschränkter Haftung, Friedrichshafen am Bodensee, Germany.

The inventors propose the subdivision of the envelope of an

Nº367,707



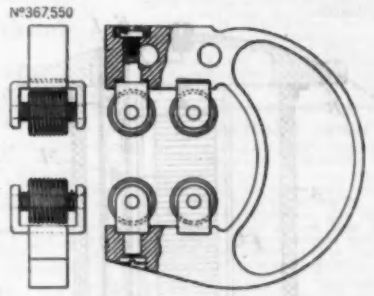
airship, as shown in the drawing, into sections, the upper series being filled with such a gas as helium, which is described as "precious," while the lower part contains combustible gas for use in the engines of the airship.—*February 25th*, 1932.

MEASURING AND TESTING INSTRUMENTS.

367,550. February 11th, 1931.—SCREW THREAD CALLIPER GAUGES, The Newall Engineering Company, Ltd., and K. E. Summers, 8, Queensway, Ponders End, Middlesex.

This invention relates to a screw thread calliper gauge of the kind fitted with pairs of rollers between which the screws are passed in radial direction. In known callipers of this kind the rollers are provided with annular ribs and grooves and it is necessary, either to deform the ribs or to adapt the rollers to be pivotally deflected in their own planes in order to compensate for the obliquity of the screw thread. Thus the construction of the calliper is, it is suggested, complicated, and when the rollers are pivotally deflected only a spot contact is obtained without proper control over the checking of the screw pitch. The object of the present invention is to obviate these disadvantages, and the invention consists essentially in providing the rollers with proper screw threads instead of annular grooves. Mostly the rollers are of the same diameter as the screws to be gauged, but for small screws the rollers are preferably made twice or three times as large as the screws and provided correspondingly with

Nº367,550

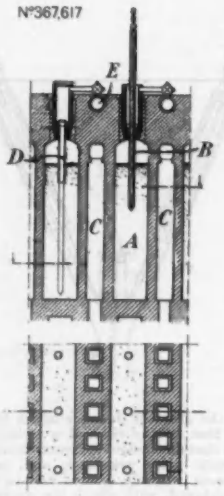


double or treble threads to obtain the proper helical angle. For instance, for ¼in. screws with twenty threads per inch, ¼in. gauge rollers may be used having ten double threads per inch. Alternatively ¼in. gauge rollers could be used having six treble threads per inch. Since the size and obliquity of the roller threads are thus identical with the threads of the screw and since the rollers are arranged axially in the same plane, a correct and complete check of the top diameter, effective diameter, crest and pitch will be obtained. The gauging rollers are free to rotate about their own axes and one or both of them are free to move endwise to the extent of at least half the pitch of the work to be gauged. Thus the rollers can be readily positioned to fit the screw. The axial displacement of the rollers may be opposed by a spring which restores them to normal position when released. Preferably two pairs of rollers are mounted in the calliper frame, one pair in front to measure the full form, and a further pair at the back to check the effective diameter of the screw. The second pair of rollers, while being provided with screw threads as already described, may be of the usual truncated and cleared root roller type in order to ascertain if the effective diameter is below the permissible limit. Means are provided for adjusting one or both of the front or back rollers towards each other for the purpose of setting the sizes.—*February 25th*, 1932.

GAS PRODUCERS.

367,617. April 10th, 1931.—Coke Ovens, C. Still, Recklinghausen, Westphalia, Germany.

This coke oven is intended for service with coals which may tend to expand during one part of the coking process and then do not contract again sufficiently to make it easy to expel the coke from the oven. The process is carried on in two distinct periods. In the first the oven A is filled with coal and into the charge there is dropped a mandrel B, which forms a passage right up through the charge. The oven is heated from the flues C C. A pipe D is then placed in the passage in the charge and

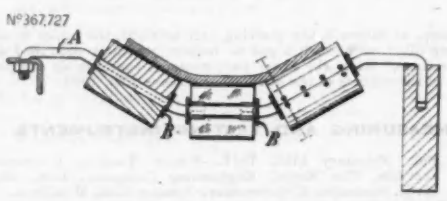


conducts away the products of distillation to the main E. The result is that there is a transverse passage of heat through the charge, which accelerates carbonisation. When there is a tendency for tar to pass into the passages made by the mandrel the pipes D are withdrawn and the remainder of the gases are drawn away from the open space above the top of the charge. It is suggested that with such a coal as that found in the Wolfsbank mines at Essen the suction during the first hour of coking should be 20 mm. and increased to about 200 mm. at about half the carbonising period of eighteen hours.—*February 25th*, 1932.

CRANES AND CONVEYORS.

367,727. August 17th, 1931.—Belt Conveyor Idlers, R. S. Prior, Summerleaze-road, Maidenhead.

This invention aims at the provision of a simple form of conveyor idler, which is cheap to manufacture and easy to assemble. Each set of idlers for a trough conveyor is mounted

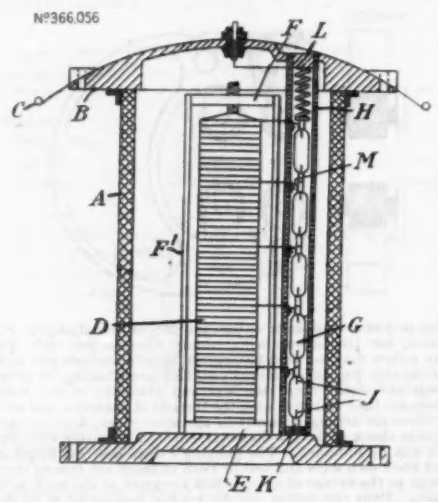


on a cranked axle A, which is provided with flanges B B, to prevent the lateral motion of those idlers. The idlers themselves are made of two pieces of, say, wood, split longitudinally, and are lagged with steel plate, screwed in place, to hold the two halves together and to provide a wearing surface.—*February 25th*, 1932.

MISCELLANEOUS.

366,056. July 25th, 1930.—Protection Against Electrical Surges, *Dubilier Condenser Company (1925), Ltd., of Ducon Works, Victoria-road, North Acton, London, W.* 3.

A surge absorber constructed in accordance with this invention consists of an insulating tube A, which is mounted on the base



and is closed by a cap B, which carries a protecting cover C. Inside this casing is a condenser body D, which is held between the plates E and F by means of the insulating strips F, and is surrounded by an insulating cooling liquid (oil). The condenser body D is subdivided into a series of elements, which are connected in series. In parallel with these are gaseous discharge tubes G, placed in the insulating tube H to the side of the condenser pile and are mutually connected in series. Each tube comprises a glass or quartz vessel with the electrodes J and the connecting caps K. The ignition potential is so chosen that the total ignition potential of the entire battery is greater than the normal voltage of the network. Preferably the tube H is so arranged that one lamp may be fixed on the other so that they come into conductive connection through the caps K and are pressed against each other by the springs. L is a closing piece which closes the tube H. The bottom tube is conductively connected through the connecting cap K to the earthed base plate, whilst the top tube is connected through the spring to the line which is to be protected. Contact springs M are secured to the connecting caps K, and when the tubes are placed in position these springs make slidable contact with contact points arranged at the inner periphery of the tube, and these contact points may be connected to suitable points of the condenser body so that the voltage of the entire condenser is uniformly distributed over the individual glow discharge tubes.—*January 25th*, 1932.

367,630. April 24th, 1931.—The Hardening of Steel and Alloy Steels, Pomosin-Werke G.m.b.H., Schmickstrasse 45, Frankfurt a.M., Germany.

This invention relates to improvements in the hardening of steels and alloy steels, which are capable of hardening on quenching—for example, chrome steel, nickel steel, silicon steel, and tungsten steel. The inventors state that they have ascertained that the heat conductivity of pectin solutions is approximately the same as that of oils, which are particularly suitable for the hardening of steel. Based on these facts, the hardening of steels with pectin solutions and pectin extracts has been investigated, and it has been found that these exhibit outstanding advantages for this purpose. Thus, it has been found possible to obtain varying results, according to the concentration of the pectin solution, so that, depending upon the concentration of the pectin solution employed, various degrees of hardness, tenacity, and brittleness of the hardened steel can be obtained. Accordingly the process of hardening is characterised in that solutions of pectin materials or of like plant colloids are used as hardening agents. These pectin substances or like plant colloids are colloidal chemical compounds of vegetable origin, which are chiefly obtained from the cell walls of plants, such as fruits and sugar beet. The pectin solutions employed according to this invention offer, as compared with steel hardening oils, the advantage of accurate adjustability. Oil, as is known, is immiscible with water, whereas mixtures of water and pectin can be prepared in any desired proportion. A further advantage is that oil is combustible, while pectin solutions are not. Since the steel is generally introduced into the hardening bath in a glowing condition, this fact is of special importance. The most important advantage is, however, the low price of the pectin solutions, which are many times cheaper than hardening oils. Yet another advantage of the process of the invention is that the hardening and tempering, which have hitherto been effected in two separate operations, can by a suitable regulation of the concentration of the pectin solution be carried out in one operation. For the hardening of steels, pectin solutions of 0·5 to 15 per cent. and over can be used. Instead of artificial pectin solutions, natural pectin extracts, derived from portions of plants, which can be concentrated or diluted as desired, can be used. When it is desired to obtain high brittleness and hardness, solutions with small pectin content are used. When, however, a steel of high tenacity and low hardness is desired, higher concentrations are used. The desired hardening effect must be exactly determined by empirical means, depending on the composition of the steel. For example, for tool steel, which should show great hardness, but be as tough as possible, about 4 per cent. pectin solution is used. The concentrations of the pectin solutions hereinbefore mentioned are expressed as percentages of dry soluble pectin substance in the solution.—*February 25th*, 1932.

Forthcoming Engagements.

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of its insertion, the necessary information should reach this office on, or before, the morning of the Tuesday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

TO-DAY.

Institution of Electrical Engineers.—Savoy-place, Victoria Embankment, W.C. 2. Joint Meeting of the Meter and Instrument Section and the Wireless Section. "Some Acoustic and Telephone Measurements," by Mr. H. R. Harbottle. 7 p.m.

Institution of Mechanical Engineers.—Storey's-gate, St. James's Park, Westminster, S.W. 1. Informal meeting. Discussion, "Training for Management," introduced by Mr. T. G. Rose. 7 p.m.

Institution of Mechanical Engineers: Midland Branch, Graduates' Section.—Chamber of Commerce, New-street, Birmingham. "Bridge Construction," by Dr. C. H. Shirley Smith. 7 p.m.

Junior Institution of Engineers.—39, Victoria-street, S.W. 1. "The Design and Manufacture of Taps, with Notes on Screwing Dies," by Mr. W. Wood. 7.30 p.m.

Railway Club.—57, Fetter-lane, E.C. 4. "The Metropolitan Railway, Past and Present," by Mr. B. Robert White. 7.30 p.m.

Society of Chemical Industry: Chemical Engineering Group.—Meeting in Sheffield. Leave Royal Victoria Hotel, adjacent to the Victoria Station, by motor coach for Hadfields' works. Visit to the works of Hadfields, Ltd. 2.15 p.m. Royal Victoria Hotel, Sheffield. "Special Alloy Steels as Applied to Chemical Engineering," by Messrs. T. G. Elliot, R. J. Sarjant, and Wm. Cullen. 6 p.m. Informal dinner, 8 p.m.

SUNDAY, APRIL 10TH.

Institution of Civil Engineers: Birmingham and District Association.—Visit to see the operation of rolling in the new bridge crossing Aston-lane on the Birmingham–Walsall line of the L.M.S. Railway. 10 a.m.

MONDAY, APRIL 11TH.

Chartered Surveyors' Institution.—12, Great George-street, S.W. 1. Meeting at 8 p.m.

Institution of Sanitary Engineers.—At Caxton Hall, Westminster, S.W. 1. "Cement," by Mr. D. B. Butler. 7 p.m.

TUESDAY, APRIL 12TH.

City of London.—The Sir John Cass Technical Institute, Jewry-street, Aldgate, E.C. 3. Commencing a series of seven lectures on "Power Plant, Diesel and Semi-Diesel Engines," by Mr. E. L. Bass. Tuesday evenings, 6.45 p.m. to 8.15 p.m.

Crystal Palace School of Practical Engineering.—Crystal Palace. 178th Award of Certificates, by Mr. A. M. A. Struben. 3 p.m.

Institute of Marine Engineers.—The Minories, London, E.C. 3. "Lubrication of Diesel Engines," by Engineer Lieut.-Commander H. J. Nicholson. 6 p.m.

Institution of Electrical Engineers: Scottish Centre.—39, Elmbank-crescent, Glasgow. Annual general meeting. "Electrically Driven Underground Conveyors in Coal Mines, and their Economic Advantages," by Messrs. W. B. Hird and J. B. Mavor. 7.30 p.m.

Institution of Engineers and Shipbuilders in Scotland.—39, Elmbank-crescent, Glasgow, C. 2. Annual general meeting. The adjourned discussion on "Propelling Machinery for Cargo Vessels" will be continued. 7.30 p.m.

Institution of Petroleum Technologists.—At the House of the Royal Society of Arts, John-street, Adelphi, W.C. 2. Symposium on "Spontaneous Ignition Temperature," by Mr. L. J. Le Mesurier, Mr. J. L. Chaloner, and Mr. F. A. Foord. 5.30 p.m.

WEDNESDAY, APRIL 13TH.

Institution of Engineers and Shipbuilders in Scotland.—Luncheon in the Ca'doro Restaurant, Glasgow. The speaker will be Bailie A. B. Swan. 1 p.m.

Royal Society of Arts.—John-street, Adelphi, W.C. 2. "Rural Industries, their Organisation and Development," by Mr. J. R. I. Brooke. 8 p.m.

THURSDAY, APRIL 14TH.

Institute of Marine Engineers.—The Minories, E.C. 3. Junior Section meeting. "Practical Hints on the Operation and Maintenance of Marine Electrical Machinery," by Mr. D. M. Cathcart. 7 p.m.

Institute of Metals: London Local Section.—In the Rooms of the Society of Motor Manufacturers and Traders, Ltd., 83, Pall Mall, S.W. 1. Annual general meeting and open discussion on "Welding, Brazing, and Soldering." 7.30 p.m.

Institution of Electrical Engineers.—In the Lecture Theatre of the Institution, Savoy-place, Victoria Embankment, W.C. 2. "An Analysis of the Costs of Electricity Supply and its Application in relation to Various Types of Consumers," by Messrs. E. H. E. Woodward and W. A. Carne. 6 p.m.

Institution of Mechanical Engineers: Yorkshire Branch.—Keighley meeting. In the afternoon members have the choice of visiting either the works of Prince-Smith and Stells, Ltd., textile machinery manufacturers, or the works of Dean, Smith and Grace, Ltd. 2.45 p.m. Followed by a reception of members by the Mayor of Keighley (Alderman Cryer) at 5 p.m. at the Town Hall; tea at 5.30 p.m. at the Town Hall; general meeting at the Technical College, Keighley, "The Trend of Modern Machine Tool Design," by Mr. H. C. Town. 6.30 p.m.

Institution of Structural Engineers.—Joint meeting with the British Section of the Société des Ingenieurs Civils de France, at 10, Upper Belgrave-street, S.W. 1. "A Sea Wall in Kent," by Mr. F. M. Du-Plat-Taylor. 6.30 p.m.

Royal Aeronautical Society.—In the Lecture Hall of the Royal Society of Arts. John-street, Adelphi, W.C. 2. "Aero-engine Accessories," by Mr. W. L. Taylor. 6.30 p.m

FRIDAY, APRIL 15TH.

Junior Institution of Engineers.—39, Victoria-street, S.W. 1. "Notes on Rocket Propulsion," by Dr. Herbert Chatley. 7.30 p.m.

WEDNESDAY, APRIL 20TH.

Institution of Chemical Engineers.—In the Rooms of the Chemical Society, Burlington House, London, W. 1. "Coal Distillation in Rotary Retorts (Internally Heated)," by Mr. Harald Nielsen. 6 p.m.

Royal Society of Arts.—John-street, Adelphi, W.C. 2. "China and the Future of Our Far Eastern Trade," by Mr. J. O. P. Bland. 4.30 p.m.

Royal Society of Arts.—John-street, Adelphi, W.C. 2. "Instalment Buying," by Mr. J. Gibson Garvie. 8 p.m.

FRIDAY, APRIL 22ND.

Institution of Mechanical Engineers.—Storey's-gate, St. James's Park, Westminster, S.W. 1. "The Film Lubrication of the Journal Bearing," by Messrs. R. O. Boswall and J. C. Brierley. 6 p.m.

Junior Institution of Engineers.—The dinner to celebrate the forty-eighth anniversary of the Institution's foundation will be held at the Hotel Metropole, S.W. 1.

SATURDAY, APRIL 23RD.

Institute of British Foundrymen: Junior Section.—In the College of Technology, Manchester. Annual general meeting. "The Merits of Oil Bonded Sands," by Mr. A. L. Key. 7 p.m.

WEDNESDAY, APRIL 27TH.

Institution of Locomotive Engineers: Birmingham Centre.—In Room 178, of the Queen's Hotel, Birmingham. "The Manufacture of Copper Fire-box Plates," by W. F. Brazener. 6.45 p.m.

Royal Society of Arts.—John-street, Adelphi, W.C. 2. "Education for Commerce," by Mr. H. Ramsbotham, M.P. 8 p.m.

THURSDAY, APRIL 28TH.

Diesel Engine Users Association.—Caxton Hall, Westminster, S.W. 1. "Cylinder Liner Wear," by Eng. Rear-Admiral J. Hope Harrison. 3.30 p.m.

SATURDAY AND SUNDAY, APRIL 30TH AND MAY 1ST.

Engineering Golfing Society.—Spring meeting at Burnham-on-Sea, Somerset. Full particulars may be obtained from the Honorary Secretary, Mr. G. H. Hopewell, Foster Wheeler, Ltd., Aldwych House, London, W.C. 2.

TUESDAY, THURSDAY, & FRIDAY, MAY 3RD, 5TH, & 6TH.

University of London.—In the Department of Applied Statistics, University College, Gower-street, W.C. 1. Advanced Lectures in Statistics. Three lectures, "The *Rôle* of Statistical Method in Industrial Standardisation," by Dr. W. A. Shewhart. 5.30 p.m. each day. Admission free.

WEDNESDAY, MAY 4TH.

National Institute of Industrial Psychology.—At the London School of Economics and Political Science, Aldwych, W.C. 2. "Psychological and Social Factors in Business Rationalisation: The Significance of Rationalisation," by Dr. Charles S. Myers. 5.30 p.m.

SATURDAY, MAY 7TH.

Institution of Electrical Engineers: Meter and Instrument Section.—Visit to Rugby. For details see page 379.

WEDNESDAY, MAY 11TH.

Institute of Metals.—In the Hall of the Institution of Mechanical Engineers, Storey's-gate, Westminster, S.W. 1. Annual May Lecture, "The Plastic Deformation of Metals," by Professor F. Körber. 8 p.m.

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